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THE JOURNAL

OF THE

Canadian Mining Institute

1903

Containing the Papers and Proceedings of the Meetings
of the Institute.

EDITED BY THE SECRETARY.

VOLUME VI.

> " The Institute as a body shall not be responsible for the statements or opinions advanced in the papers which may be read, or in the discussions which may take place at its meetings."—*By-Laws, par. xxxii.*

PUBLISHED BY AUTHORITY OF THE COUNCIL
AT THE SECRETARY'S OFFICE, ORME'S HALL, OTTAWA,
1ST MARCH, 1904.

DECEASED MEMBERS.

G. R. Coates,	Mine Centre, Ont.
James MacGregor,	Nanaimo, B.C.
W. J. Nelson,	Montreal, Que.
Maurice A. Buck,	Kalso, B.C.
Col. T. J. Tuck,	Sherbrooke, Que.
H- A. Budden,	Montreal, Que.
James King,	Quebec, Que.
W. Barclay Stephens,	Montreal, Que.
James Foley,	Montreal, Que.
Dr. Carl Hoepfner,	Hamilton, Ont.
G. A. Bielenberg,	Greenwood, B.C.
Dr. G. M. Dawson,	Ottawa, Ont.
Lionel H. Shirley,	Montreal, Que.
James F. Lewis,	Sherbrooke, Que.
I. Roderick Robertson,	Nelson, B.C.
Dr. A. R. C. Selwyn,	Vancouver, B.C.
Capt. R. C. Adams,	Montreal, Que.
James Cooper,	Montreal, Que.
Col. King,	Sherbrooke, Que.
John McAree,	Toronto, Ont.

THE LATE DR. A. R. C. SELWYN, C.M.G.

Director Geological Survey of Canada, 1869 to 1895.

THE LATE CAPTAIN ADAMS.

THE LATE MR. JAMES COOPER, MONTREAL.

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REPORT OF COUNCIL, 1902.

The Council of the Canadian Mining Institute take pleasure in submitting the Fifth Annual Report on the proceedings of the Institute during the year 1902. It is with much satisfaction that they are able to state that the period under review has been one of increasing prosperity and progress in all the operations of the Institute.

MEMBERSHIP.

The growth of the membership and its distribution will be seen from the following comparative statement:—

—	1898	1899	1900	1901	1902
Nova Scotia	16	16	19	27	31
New Brunswick	2	1	2	2	1
Quebec	66	77	77	77	79
Ontario	44	68	91	83	107
British Columbia	42	65	72	67	72
Manitoba	..	..	..	..	2
Newfoundland	..	1	2	2	2
Alberta	5	5	5	6	6
Yukon	..	..	..	2	5
Great Britain	4	9	7	12	14
United States	11	17	26	30	36
China	..	1	1	1	..
Honolulu	..	1	..	..	1
Spain	..	1	2	2	1
Australia	..	..	..	..	1
South Africa	..	..	3	4	..
Alaska	..	..	1	..	..
Mexico	..	..	1	1	1
Labrador	..	..	..	1	..
East Africa	..	..	..	1	1
South America	..	..	..	1	1
Students	2	15	14	12	92
	192	277	323	331	453
Died during the year	2	4	4	4	2

During the twelve months over seventy names were added to the list of active members, and in consequence of the affiliation of the

Mining Societies of McGill and Queen's Universities, the student membership was also considerably increased, the number of students on our roll at present numbering ninety-two.

The migratory character of certain branches of the mining profession is well known, and we have, in consequence of members leaving the country, again to report a number of resignations. A few names have also been removed for arrears of subscriptions.

OBITUARY.

It is with profound sorrow that the Council places on record the deaths of Captain Robert C. Adams, of Montreal, and Dr. A. R. C. Selwyn, of Vancouver.

Captain Adams was very well known to many of you as one of the founders and first presidents of the General Mining Association of the Province of Quebec, and later as a member of the Executive of the Federated Canadian Mining Institute, which preceded our present organization. He was of an extremely lovable disposition, a man of high character, and, possessing considerable ability as a speaker and a writer, he was for many years a conspicuous figure at the meetings and conventions which, since 1889, have been held annually at this time of year in this room. He will long be remembered by the mining fraternity in Quebec for the keen interest he took in promoting any effort having for its object the welfare of the profession and industry of mining, and particularly for the splendid services which he rendered to the mining industries of Quebec at a time when their existence was threatened by ill-considered and repressive legislation.

Dr. A. R. C. Selwyn, C.M.G., occupied the honored position of Director of the Geological Survey of Canada from 1869 to 1895, and at the time of his death was one of our honorary members. Although not so well known to the present generation of mining men, Dr. Selwyn, when Director of the Survey, accomplished much for the advancement of Geological Science in Canada, and his numerous published reports of his explorations and investigations have greatly extended our knowledge of the resources of the Dominion. At our last Annual Meeting the Institute gave testimony of its appreciation of Dr. Selwyn's services to Canada by the presentation of his portrait in oil to the Museum of the Survey at Ottawa.

MEETINGS.

The Annual Meetings of the Institute were held in this place in March. All the sessions were well attended, and much interest was taken in the papers and discussions.

Pursuant to a Resolution to form sections of the Institute at various mining centres, meetings were held in Kingston, Ont., at Sherbrooke, Que., and at Nelson, B.C., and branches organized at these points. Of these meetings the British Columbia one was particularly successful. A number of interesting and valuable papers were read, and many new members elected.

PUBLICATIONS.

During the year no less than fifty-one papers were presented by members, and of these forty-one were published in Volume V of the Journal of the Institute. This large, handsomely bound and profusely illustrated volume was issued to members in August, and will, it is hoped, be found to be a work of considerable service and value, not only to the members, but to the mining profession. Numerous copies were donated to the libraries of the principal mining, engineering and technical societies in Canada, Great Britain, South Africa, Australia, New Zealand, New South Wales, India and the United States. Indeed the demand for copies has been so great that our supply is completely exhausted, and in the future it will be necessary to provide for a very much larger issue.

The papers read before the British Columbia meeting have also been printed, and will be included in Volume VI.

The publication and distribution of so large a volume of our Transactions, and the heavy cost entailed by the redrawing and engraving of the numerous maps, plans, sketches and photographs which accompany it, together with the expense of printing and mailing several thousand copies of the papers in pamphlet form, has been aided very considerably by an increase in our grant from the Dominion Government, obtained, we are pleased to say, through the generous consideration of the Hon. the Minister of the Interior, Mr. Sifton.

As our expenses of publication must naturally increase from year to year with the growth and advancement of the mining industries in Canada, the Council hopes that the Hon. Mr. Sifton, who is keenly alive to the importance and necessities of our mineral development, may be induced not only to renew the grant for the ensuing year, but to make it an annual one

STUDENTS' COMPETITION.

Seven papers, four from McGill and three from Queen's, were contributed by student members in competition for the President's gold medal and the prizes annually offered by the Institute. Every one of these welcome contributions to our Transactions possessed merit, but they covered subjects so widely diverse in character that sub-committee appointed by the Council to make the award had the greatest difficulty in arriving at a decision. Mr. C. V. Corless, who sent in a highly meritorious review of the geology and ore deposits of South Eastern British Columbia, withdrew his paper from the competition, and the awards were finally made as follows: President's medal to O. N. Scott, Listowel, Ont., for his paper describing "The Ore Deposits of Copper Mountain, Similkameen District, B.C." Cash prizes of $25 each to Mr. H. W. DePencier, McGill, for his paper describing "Mine Timbering in the Old Ironsides and Knob Hill Mines," and L. P. Silver, Queen's, for his review of "The Sulphide Ore Bodies of the Sudbury Region."

With the object of remedying the difficulty of making these awards in the future, the Council recommend that in addition to the President's medal three cash prizes of a value of $25 each be offered annually by the Institute for papers contributed in the following divisions:—

GROUP I—*Ore Deposits and Mining Geology.* The subject may be treated generally, or some particular district or single deposit may be discussed or described.

Group II—*Mining Practice.* Any and every branch of mining may be treated, such as pumping, hoisting, ventilation, timbering, ore extraction, development, etc., etc., or some particular method of mining, or some individual mine or group of mines, may be described or discussed.

Group III—*Ore Dressing and Metallurgy.* Any branch of ore dressing or metallurgy may be treated, as for example: Crushing, jigging, milling, concentrating, smelting, roasting, cyaniding, etc., or some particular plant may be described or discussed.

VISIT OF THE LAKE SUPERIOR MINING INSTITUTE.

In accordance with a Resolution passed at the Annual Meeting, an invitation was extended to the Lake Superior Mining Institute to join us in a meeting at Sault Ste. Marie, Ont., to be held in the month of August. The secretary of that society, however, wrote that arrangements had already been made for their summer meeting in 1902, but that if the invitation was kept open for 1903 a joint meeting might be arranged. It is, therefore, proposed to hold a meeting of the two organizations at Sault Ste. Marie in August or September, thereafter visiting the copper and iron mines of the vicinity and the copper-nickel mines of Sudbury. The Hon. the Commissioner of Crown Lands for Ontario has promised a grant of one thousand dollars to aid in making these meetings and excursions a success.

LIBRARY AND READING ROOM.

The Library and Reading Room has been kept open daily during the year, and has been largely used by members and by visitors seeking information concerning the mineral resources and mining industries of the country. The collection of works on mining, milling and metallurgical practice, books of reference, exchanges from kindred societies, magazines and papers, maps, plans and photographs, have been considerably extended, and it will be necessary to provide another book-case for the accommodation of this now very valuable collection.

FINANCES.

The audited statement of the Treasurer, which will be submitted to you in detail at the annual meeting, shows our finances to be in an exceedingly satisfactory condition, the cash balance on hand at 31st January, the end of our financial year, amounting to $1,632.49. As showing the growth of the Institute the following comparative statement of our receipts and disbursements will be of interest:—

	Receipts.	Disbursements.
1898	$2,674.67	$2,454.85
1899	3,421.10	3,156 05
1900	3,601.50	3,455.76
1901	4,076.50	3,749.71
1902	6,330.89	5,655.80

Submitted on behalf of the Council.

CHARLES FERGIE,
President.

B. T. A. BELL,
Secretary.

CANADIAN MINING INSTITUTE.

Treasurer's Statement—Year ending February 1st, 1903:—

RECEIPTS.

Balance from last year		$957.40
Subscriptions, 317 at $10.00	$3,170.00	
Students, 6 at $2.00	12.00	
University members, 82 at $1.00	82.00	
Arrears collected	104.00	
		3,368.00
Sale of Journals		6.00
Sundries		6.89
Dominion Government Grant		3,000.00
		$7,338.29

LESS.

Disbursements per Statement		$5,655.80
Balance on hand		$1,682.49

J. STEVENSON BROWN,
Treasurer.

Montreal, February 1st, 1903.

Audited and found correct.

(Signed) H. W. DE COURTENAY.
" GEO MacDOUGALL.

Summary Statement—Showing Distribution of Disbursements to the various Work and Business of the Institute:—

Publications—		
Transactions	$1,290.57	
Cuts, line drawings, half tones and engraving	512.33	
Reporting, typewriting, proof reading, etc.	633.67	
Stenography, copying, etc	160.00	
Postage, express and other charges	159.80	
		$2,756.37
Library—		
Rent	$400.00	
Care of library	96.00	
New books	41.40	
Binding	26.80	
Insurance and other charges	90.81	
		655 01
Meetings—		
Reporting Annual Meeting and Secretary's disbursements	$206.45	
Annual dinner	93.30	
Disbursements per Treasurer	23.85	
Council Meetings	73.85	
Postage, telegrams, advertising and sundries	110.65	
Inaugurating branches at Kingston, Sherbrooke and Nelson, traveling expenses, reporting, advertising, etc.	157.80	
		665.90
Legislation and Deputations—		
Civil Engineers' Bill	55.00	
Deputation to Toronto re summer meeting	35.00	
Deputation to Ottawa re annual grant	75.40	
		165.40
Secretary's Office—		
Annual grant	$800.00	
Postage and telegrams	56.50	
Stationery and sundries	62.76	
		919.26
Treasurer's Office—		
Annual grant	350.00	
Bank charges on cheques and drafts	67.20	
Postage and telegrams	35.96	
Stationery and sundries	30.70	
Audit	10.00	
		493.86
		$5,655.80

Montreal, February 1st, 1903.

J. STEVENSON BROWN,
Treasurer.

Mine Development Methods.

By B. J. Forrest, C. & M. E., Broad Cove, C B.

Prospecting.—In coal formations have found outcrop indications first to prove. Secondly, drifting from outcrop if this exists; if not, thirdly, boring to or through the carboniferous measures and locating and finding dip, strike and contour, and number of seams, and if possible direction and throw (up or down) of faults, with a view of sinking to and opening out from dip side of measures or faults, and reducing future cost of development and working, such as getting and haulage of coal, pumping of water, intersection of faults, etc.

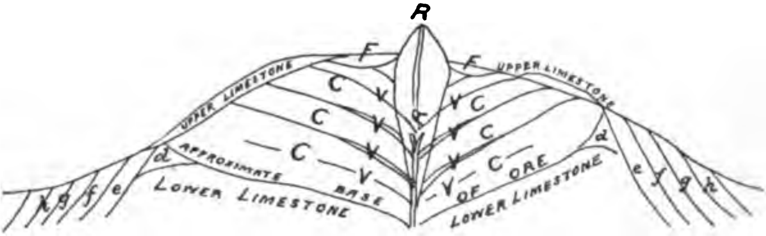
In iron formation, when stratified, similar methods will obtain, and in more stratified formations, survey with dip-needle, plane-table, aneroid (and cacheometer, if necessary), to locate strike and dip and contour; then area and thickness, by drifting, blocking and drilling. Drifting, the generally more expensive, I have generally found more trustworthy as regards testing of capacity and areas of deposits; drilling, though cheaper, is not so reliable or certain of satisfactorily proving iron formations or deposits, such as are commonly met with in Ontario and Nova Scotia, *e. g.*, magnetite interbedded with green schists, diorites and felsites, titaniferous magnetites mixed with eruptive rocks and conglomerates.

The upper and lower Cambrian measures, so far as I have been able to observe, appear to have the largest and most easily workable or conveniently placed bodies of ore for economical working or development, the ore-bodies or deposits occuring in post glacial formations in Ontario, appear to be more irregular than those in the Cambrian measures, though this supposition requires further investigation as there appearsto existsome intermediate iron formations between the Huronian and Cambrian series. The Bilbao iron ore formations in north of Spain (of hydro-thermal origin) are found associated with upper and lower cretaceous formations and deposits of limestone, clay and sandstone conglomerates—the Triano or central formation having approximately the following transverse contour (see sketch). In prospecting with drills the probabilities of intersection in a pockety or irregular bedded formation of iron ore, vary considerably with class of deposit, lode, bed or spur, *i.e.*, the chances of satisfactorily proving extent, area, or capacity of irregularly stratified deposits vary more or less, as follows, *e.g.*, see sketch :—

1 to 2 drill holes through lode or seam *c.*—Vertical holes, depth 40% to 100%.
1 to 3 " " " *d.*— " thickness 0% to 50%.
1 to 4 " " " *e.* } At angle of 45° (right and left)—depth and
5 to 3 " " " *j.* } thickness from 20% to 30%, or the mean
6 to 3 " " " *g.* } average of chances of proving lodes by
A, *B*—Drift. [drill would be from 40% to 60% of actual areas.

By drift A, B—thickness 100% depth 0% to 100%. By drift at angle of 45° = 40% to 100%, and proportional to depth below summit and level of line *A*, *B*.

The advantage of drifting in like deposits is that not only can strike, dip and capacity be proved, but class and extent of bed and hanging rock and adjacent strata—sampling, water-feed, etc. The percentage of extent or capacity proved would also depend on amount or extension of cross and vertical drifting, drilling, sinking and blocking carried out from said level, a considerable extent of which might be proved by drilling of breast and flank holes from said levels.



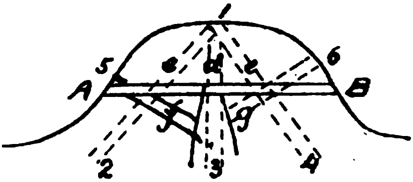
SKETCH OF BILBAO, TRIANO, IRON ORE FORMATION.

Observations.—R. Rubio ore, cindery honeycombed appearance, containing about 56 per cent. metallic iron, with a large quantity of fireclay and silicious earths mixed with it. V. Vena, or soft vein of ore, running through centre of ore bodies, very rich soft ore averaging 65 per cent. of metallic iron. C. Campanil, or main body of ore, good hard hematite, about 60 per cent. of metallic iron ; these ores average about 0.02 to 0.08 phosphorous and from 2 per cent. to 8 per cent. silica. *d.* Siderites, in pockets and layers. *e*, *f*, *g*, *h*. Schistose grits, siderite, limestone and sandstone. F. Fireclay.

Comparisons of Cost of Proving and Testing Deposits.—This would depend greatly on class of formation, extent of blocking, drifting and drilling carrying out. The ratios of cost would vary—*e. g.*, drilling by diamond drill from $5 to $8 per lineal foot, increasing with length, depth and size of hole.

Shafts.—Would also vary with depth and area from $6 to $10 per lineal foot, increasing with depth, amount of water struck, and cost of winding, haulage and ventilation.

Drifting and Blocking.—From $6 to $9 per lineal foot, increasing with area, amount of propping or steining, distance and dip from shaft or main drift, length and angle of haulage, winding, ventilation, and water struck. Cross drifting and blocking from main shaft or level would cost from 15 per cent. to 20 per cent. more under similiar conditions.



I have generally found drill work more satisfactory or suitable in testing of coal areas or similar formations, but not so effective in proving irregular lodes or deposits, except in those more extensive and regularly stratified, such as found in Newfoundland, Spain, Portugal and South America.

Developing.—If possible and convenient, and extent of overburden, spurs, faults or stripping too thick or interbedded, open-cast cut or quarrying is preferable to mining, providing lifts and length and depth of working faces and levels are at a convenient and economical working height and distance, in relation to gravity and point of delivery, and the disposition of mining and transporting gangs, plant and machinery, such as air compressors or steam drills, crushers, transporting plant, tracks, chutes, bins, etc., and if conveniently situated and apportioned to area, length and output from working faces or levels, and number of men that can be economically employed on each face or working level, and their position with regard to point of delivery, classification of ore, gravity, tracks, etc.

System of Transport and Haulage.—If distance short and gravity available, chutes and inclined planes would probably serve the purpose. If distance long and contour of ground regular, endless, or tail-rope, or Lidgerwood cable systems might serve. If distance long and contour of ground irregular or very steep and undulated, wire cable-ways, steam or electric trams or railways would serve better, and if fluvial transport available, would be cheapest.

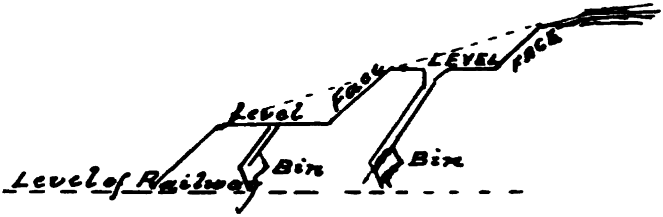
The approximate rates of cost of above named systems would vary more or less as follows, viz.:

Inclined Plane.—Transport, from 10 to 16 cents per ton mile. Cost, from $10,000 to $15,000 per mile.

Endless and Tail-rope Systems.—Transport, from 12 to 17 cents per ton mile. Cost, from $12,000 to $15,000 per mile.

Wire Cable-ways.—Transport, from 12 to 17 cents per ton mile. Cost, from $10,000 to $15,000 per mile.

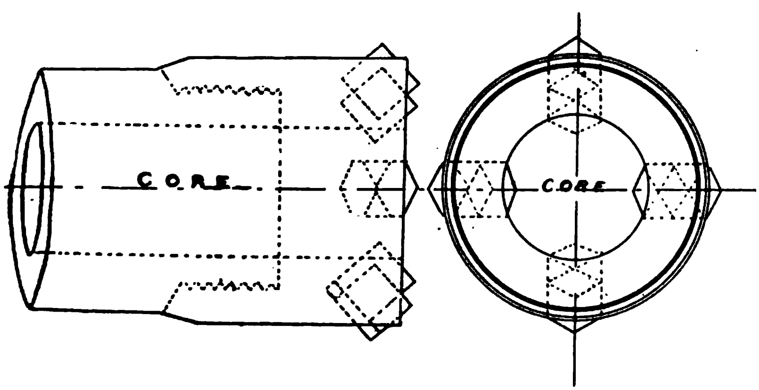
Varying proportionally with single and double lines, self-acting or if driven by steam or electric power, and contour of ground traversed, with the advantage that it is easily removed and re-erected if necessary. This system is generally suitable for mines and quarries difficult of access and working and of doubtful output and capacity. If mines or deposits are proved to be of large capacity and productive, would recommend running railway cars right into and under main working levels and faces, thus reducing cost of handling and transport of ore. If water transport available and point of delivery great, cost would be still less.



Drilling Plant and Machinery.—This depends on class and position of ore and work; generally compressed air is preferable to steam or hydraulic power in deep or irregular open-cast or underground work, shafts and drifts, on account of drainage, ventilation and non-formation of water damp, heat and gases, loosening of cover and swelling of bottom; of top, bottom or side stripping, when sinking, drifting or blocking.

Class of Drill.—This depends on class, position and nature of ore and work to be dealt with, and whether under or over ground, vertical or under-cutting or holing work is to be carried out. The diamond drill, if true (not faked) Brazilian carbonates are used and carefully set in suitable bits, and experienced or skilled men employed, is well suited for any class of deep vertical or flank holing in hard irregular formations; though the Calyx drill has done some first-class work in hard rock, and the renewal of bits is not so costly and risky. With a view to reduce cost of replacing diamond drill bits, I have experimented a little with corundum crystals, which are next in hardness to diamonds, (viz: diamond, 10h; corundum crystal, 9). I think a fair percentage of boring done by diamond drill might be done with them; the main points to solve are the size and pitch, and setting and cutting angles, and fixing metal of bit and crystals used. So far, my experiments lay in the following lines (see sketch):—

—— DRILL BIT (FULL SIZE)



Progress in Magnetic Concentration of Iron Ore.

By Mr. J. Walter Wells, Toronto, Ont.

Introduction.—The future supply of iron ore is a problem which far sighted iron masters are at present investigating, as the present available supply is not calculated to last for many years.

Already the English and German iron works are importing ores from Spain and Sweden. In the United States the present available supply of high grade ore is not calculated to last more than 40 years, while the supply in Canada is apparently no more abundant, so that it becomes a proper subject of inquiry as to the best means of utilizing the immense beds of low grade iron ores.

The production of pig iron continues to increase rapidly, for example in 1901 the total production of pig iron in the United States was, according to official statistics, 15,878,854 long tons valued at $242,174,000, using 28,887,476 tons of iron ore, being nearly twice the production in 1896. In 1900 Canada produced 86,090 long tons of pig iron, while in 1901 the production rose to 244,976 tons, and is likely to increase rapidly. Iron ore cannot be said to reproduce itself in the same manner as forest or animal wealth. Iron masters are facing a constantly decreasing supply of high grade iron ore along with a constantly increasing consumption, so that sooner or later the low grade ores will be drawn upon. And it may be advisable to concentrate the low grade ores before using them in the furnace.

What is Concentration?—To the engineer concentration means the separation of the wheat from the chaff—the elimination of the worthless rock from the valuable ore. According to present practice in concentrating iron ores there must be some difference between the constituents of an ore either in hardness, specific gravity, or in magnetic permeability that is the relative susceptibility to a magnetic influence, in order to allow a separation of the particles. For example, it is comparatively easy to separate a granular hematite imbedded in a calcareous gangue. The calcite being softer than the hematite will crush finer for the same treatment, and as it is of relatively less weight than the hematite, a system of crushing, sizing and treating in a pulsating jig removes the gangue from the ore,

Again, a hard dense magnetite associated with a soft schist would be amenable to concentration, as the schist would crush finer than the ore, the resultant product, after sizing in hydraulic classifiers, being readily separated by jigs into heads consisting of pure ore, and tails consisting of worthless rock.

Both the jig and the hydraulic classifiers depend on the difference in specific gravity of the different constituents. In the case of the common mixture of magnetite with pyrite both of about the same hardness and specific gravity, a system of water concentration would not give satisfactory results. But, fortunately, an electro-magnet has a greater tractive influence on the magnetite than on the pyrite, so that we have a means of eliminating the pyrite from the magnetite when the grains of each constituent are entirely detached. How this may be done will be shown further on.

Reasons for Concentrating Iron Ores.—As iron ore cannot be said to be reproductive, the constantly increasing demand for iron along with a decreasing supply of high grade ore will force the smelters to use low grade ores, or find some means of enriching them at the mine, in order to meet requirements in the furnace. The iron master demands as pure an ore as possible in order to make a cheap and high grade pig. For example, the standard ore of Bessemer grade on which all payments are made by most of the American dealers carries 63 per cent. iron, 0.045 per cent. phosphorous, 0.05 per cent. sulphur, and the per cent. of sulphur and phosphorus cannot exceed this limit without lowering the selling price of the ore. In smelting an ore high in iron contents less fuel, less fluxing material, and less labor are required than in using a lean ore. Besides, the stock piles are likely to be more uniform, so that less trouble is required in making up the charges for the furnace burden.

The blast furnace is practically a concentrating as well as a reducing machine. All of the constituents of the ore, except a portion of the metallic contents, are separated into worthless slag, while the valuable pig iron is saved. Immense sums of money are annually spent in mining, transporting and fluxing in the smelter, slag-making material in the ore.

A modern blast furnace costs considerably more than a modern concentrating plant, both as regards original outlay and cost of maintainence. When the gangue or worthless part of the iron ore is treated in the blast furnace it must be transported, handled at least twice, melted and fluxed. By removing this gangue at the mine all of the expense of hauling, handling and eliminating in the furnace may be saved, and the ore will command a higher price at the smelter, as being a high grade uniform ore. According to present practice it takes one ton of coke to make one ton of pig iron. Most metallurgists will admit that about 400 lbs. of the coke is sufficient to reduce the iron in the oxides, while the remaining 1600 lbs. are used up in melting the pig iron along with a mass of siliceous and earthy matter making up the slag. Of course a portion of this waste heat is saved in the form of gas used to heat the air blast, but a large quantity goes to heating, fluxing and getting rid of the extra amount of slag due to gangue matter in the ore. Hence it may be seen that it is better, from the metallurgist's point of view, to concentrate the ore at the mine rather than in the furnace.

The question may be resolved into a business proposition—will it pay to concentrate the ore at the mine?

If the extra price which the concentrated ore brings at the smelter, together with the cost of hauling gangue material in the low grade ore, is greater than the cost of concentrating the ore at the mine, then the operation will be a profitable undertaking. It cannot be profitable to deliver concentrated ore to the smelter in competition with an equally rich ore in the natural state, the costs of transportation being the same. But rich ores in the natural state are not abundant, so that there is always a chance for the concentrated ore to come into the market.

Methods of Concentration.—Hence it becomes a pertinent subject of investigation to determine the most efficient method of concentrating iron ore at the mine.

The simplest method of concentrating hard iron ores is by hand-cobbing, the laborer breaking up the ore to small sizes with a sledge hammer, picking out the good ore for use in the smelter, throwing the worthless rock to the waste heaps. In the case of soft iron ores intermixed with clay, different forms of washers are used. The log-washer commonly used in the southern United States, is a tilted cylinder rotating on its longer axis, with side paddles forcing the ore upwards in a trough against a descending current of water, washing away the clay and fine material through a screen at the lower end, while the washed ore passes to the ore cars at the upper end.

In concentrating hard iron ores the product should have the coarsest possible size together with the highest possible purity to meet requirements of the market. The cost of crushing depends on the fineness of the desired product. The required fineness depends on the physical character of the ore—whether it is fine or coarse grained, whether the gangue is readily detached from the particles of ore. The cost of separating the ore, per ton of finished product, varies with the richness of the ore, that is, the number of tons of crude ore which must be crushed to a certain size to obtain a certain concentrated product, is an item of importance on the cost sheets. The richness of the ore depends on the amount of gangue material present, so that a complete petrographical examination of an ore will give you a fair idea of how it will work by any system of concentration. For example, an ore is shown in Plate I will be easily treated, as the coarse grains of iron ore can be readily detached from the segregations of rock without fine crushing. Plate II shows a section of an ore which is amenable to coarse concentration for the same reason. Plates III and IV show samples of ore which require quite fine crushing in order to completely separate the ore from the rock, while Plates V and VI show ore that is not amenable to any cheap method of concentration, owing to the fine particles of ore being so intimately intermixed with rock matter that very fine crushing is necessary, the product requiring briquetting before use in the smelter. It often happens that pyrite or apatite occurs in an ore which carries high iron values, but yet the ore is of no commercial value owing to the objectionable constituents. These deleterious constituents may be separated by magnetic concentration, and it is only a matter of how fine is it necessary to crush in order to detach the grains of the ore from the grains of the other constituents. For example, Plate VII shows an ore in which the pyrite shows as light colored stringers and segregated masses, while the ore shows dark colored. Such an ore requires only medium fine crushing, to a size of about 0.25 inch diameter to separate the pyrite from the ore. Plate VIII shows a dark colored dense magnetite with finely disseminated particles of pyrite scattered through the mass, to be seen in the photo as light colored particles. In this ore it is almost impossible to eliminate the pyrite without very fine grinding, as particles of ore of even 0.10 inch diameter will have particles of pyrite clinging to them. Although fine crushing would eliminate the pyrite it could not be a commercial success at present, owing to cost of fine crushing and the consequent briquetting of the fine ore.

When by petrographical means the character of an ore is determined, it is necessary to determine the best method of concentration adapted to a particular ore.

In discussing the merits of water concentration, local conditions in Canada are against its use, as iron ore requires handling in large quantity to be profitable, which entails a costly plant, consisting of jaw crushers, rolls, screens, jigs, expensive water piping, heating arrangements, and large power capacity. The product is not always high grade, as the gangue may have the same specific gravity as the ore, and it is not always possible to eliminate sulphides and apatite.

If the iron in an ore occurs in such a state that it may be attracted by an electro-magnet, then we have a simple method of separating the valuable ore from the worthless rock. Magnetites are most readily attracted by magnets, hence such ores lend themselves most readily to treatment. By increasing the strength of the magnet, hematite may also be separated out as a magnetic head. Local conditions in Canada favor magnetic concentration, as there is abundance of cheap water power available in the iron districts, while no expensive plant is necessary. The electric power may be used in running hoists, pumps, lighting system, compressors for air-drills, crushing machinery, and the product may be hauled to nearest shipping point by electric trams. Cold weather has little influence on electric power, while condensation of steam, freezing of water and air-conveying pipes, often give trouble during a cold season. Magnetic concentration depends on difference in magnetic permeability, that is, some minerals are more susceptible to the influence of a magnet than others, so that they may be attracted, held, or drawn away from other minerals not so susceptible, thereby effecting a separation. The magnetic permeability of different minerals has been worked out by Walter Crane (Transactions of American Institute of Mining Engineers, 1901) who arranges the most magnetic minerals in the following scale in descending order of permeability, thus:—

Magnetite
Franklinite
Ilmenite
Pyrrhotite
Hematite
Siderite
Limonite

The ideal method of crushing an iron ore for magnetic concentration would be to detach the different grains from each other without further crushing. Coarse crushing should be the rule rather than pulverization for two reasons: (1) It is a waste of energy to reduce the ore finer than is necessary. (2) Fine ore, as dust, is not desirable for use in the blast furnace. Hence in any system of concentration the essential point is to find out what degree of fineness is necessary to release each individual particle from its neighbor. If the ore is crushed coarse, in many ores a magnetic portion will drag a non-magnetic portion attached into the heads, thus lowering the quality of the heads. If the ore is crushed too fine there will be an adhesion of magnetic particles with the non-magnetic, preventing a clean separation, unless the ore is handled in water as by the Grondal-Delwik or Heberle separators, or by air blast as in some of the dry separators. Besides, the iron master objects to using ore in the form of dust in the smelter. Hence it may be seen that each ore is a problem in itself, requiring careful experimental investigation to determine the best method of treatment, including the size of grain, the kind of separator best adapted, the pole, distance, etc. An encouraging feature of magnetic concentration is that sulphur in the form of pyrite, and phosphorus in the form of apatite, may be eliminated from many iron ores producing a Bessemer grade. Sulphur in the form of pyrrhotite cannot be separated from magnetite, nor can phosphate of iron and phosphide of iron be readily eliminated, as they are more or less magnetic and go into the heads. Experiments conducted by the writer have shown that in some titaniferous ores the titanium may be eliminated, but in pure illmenite it is impossible to reduce the percentage of titanium by magnetic concentration.

Present Status of Magnetic Concentration.—The application of electro-magnets as a means of concentrating ores is not a novel idea, but its use on a commercial scale for concentrating iron ores, has been extended within the last 15 years.

In 1866 the late Dr. Sterry Hunt, of the Canadian Geological Survey, showed that a concentration by magnets was successful on the iron sands on the north shore of the St. Lawrence River. A charcoal iron smelter was started at Moisie, making a good grade of charcoal iron, but could not compete in price with Swedish iron, and the project was abandoned. The different types of magnetic concentrators which have met with more or less commercial success may be divided into four classes :—

(1) Those with the ore on conveying belts passing a magnetic field. Examples are the Conkling, Wetherill, Chase, Hoffman, Kessler, etc.

(2) Those with the ore on a rotating cylindrical drum within which are magnets. Examples are the Ball-Norton, Heberli, Wenstrom, Buchanan, Sautter, Siemens, Payne, etc.

(3) Those in which the ore falls vertically past magnets. Examples are the Edison, Heberli, Grondal-Delwik, Rowand, etc.

(4) Those in which static electricity is utilized, materials conducting the charge being repelled from those which do not become magnetized. The only example is the Blake-Morscher type recently invented and used at Colorado Zinc Works for separating zinc from lead ores.

It is beyond the scope of this paper to discuss the relative merits of the different machines, but a brief description of a few in commercial use may be of interest.

The Conkling separator is an endless travelling belt with three cross belts running at right angles to the main belt, underneath magnets of different strengths, as shown in Plate IX, delivering different grades of ore. The non-magnetic tails are carried along the belt. This machine does not appear to have had much success. An improved form, as described in Transactions of American Institute of Mining Engineers, 1890, was used at the Tilly Foster mine in New York State, with success.

The Wetherill separators are made in several different forms, adapted to suit requirements. Two types used at the Magnetite mines of Witherbee, Sherman & Co., Fort Henry, New York, for concentrating a magnetite carrying siliceous matter and apatite, may be described. The Rowand type, designed for highly magnetic ores, is shown in Plate X, being a diagrammatic vertical section. The crushed ore falling from a zig-zag delivery spout, thus shaking up the particles, passes a revolving drum, alternately composed of brass and iron, and magnetized by induction from the permanent magnet. The non-magnetic particles fall past the magnet, while portions are held to the periphery till the centre of the lines of magnetic force between the magnets is reached, and as this zone is neutral the particles fall. Provision may be made to classify the material into several grades, by baffles, as seen in the plate. The construction of the rapidly rotating drum may be seen in plate IoA, showing that a secondary concentration takes place, the magnetic material arranging along the bands of iron, while the non-magnetic is thrown into the alternate spaces along the bands of brass. There is also a concentration of the lines of force at P, owing to the point of the magnet projecting, and as all material passes through this field of strong magnetic forces, it may be seen that there is little iron allowed to escape in the tails, while only a weak current may be necessary owing to the concentration of the force. This type of concentrator is used at Port Henry, treating a crude ore carrying about 45 p. c. iron and consisting of magnetite, apatite, hornblende, quartz, etc. The ore is crushed to 0.25″ size, passed through the magnetite separator delivering heads carrying 69 p. c. iron. The tailings are passed through a Rowand (Wetherill system) cross belt machine, removing the hornblende as a magnetic product, leaving the tailings as almost pure apatite sold to fertilizer makers.

This machine designed for treating weakly magnetic material is shown in Plate XI. The cross-belts run under very strong magnets delivering material according to the strength of the magnet, while the non-magnetic material passes along the wide belt as tailings. The writer saw this machine remove illmenite as one product from a sample monazite sand, cerite earths as a second product, leaving garnets, quartz, etc, as tailings. The separators made by the Wetherill Separating Co., in one form or another, are able to remove garnets from corundum, siliceous matter, pyrite and apatite from iron ore, garnets from diamonds such as at De Beers Mines, Kimberly, South Africa.

The concentration of monazite sand by these machines gave an impetus to the industry of collecting rare earths for use in making incandescent mantles for lighting while the concentration of zinc ores, such as franklinite at Franklin Furnace, New Jersey, is being done on a large scale. The machine will no doubt find still further industrial uses.

The Ball-Norton separator in practical use for the last 10 years has the following distinguishing features, according to the inventor, Mr. C. M. Ball, Rockaway, New Jersey:—

(1) A stationary range of magnetic poles of alternately opposite polarity in the direction of the ore travel underneath, while the drums enclosing the two groups into which the range of poles is divided may be rotated, and may serve as carriers of the granulated ore, the iron particles being held upon the under side thereof by magnetic attraction.

(2) Means for applying a counter currrent of air to the moving mass of ore, while it is suspended upon the under side of the rapidly running drums and being driven along through the machine.

(3) Provisions for differentiating the ore into three grades, this being done by differential speed of rotation of the two drums, assisted by relative adjustments of the strength of magnetism in the two groups of alternating magnets.

In Plate XII the operations of the machine may be seen, the diagram being a section. The crushed ore is fed into the hopper at the right, the tails falling directly underneath while the larger and stronger magnet carries magnetic material to the second or weaker magnet, where a middle product, consisting of ore mixed with rock matter attached, falls down while the heads go into the hopper at the left. A blower forces air in the opposite direction of the ore travel. The particles of ore are tumbled about while suspended on the underside of the drums by being passed through magnetic fields of successively opposite polarity. Gravity, centrifugal force and a counter current of air, act at same time to eliminate the non-magnetic particles. The writer recently visited the concentrating plant of the Hibernia mines, New Jersey, as shown in Plate XIII, where the Ball-Norton machines are in use. At this mine there is some 80,000 tons of refuse ore, consisting of magnetite, hornblende, quartz, etc., being the result of several years of hand cobbing. The refuse ore carrying 40.34 p. c. iron as per samples taken by the writer, is crushed in jaw crushers, passed through rolls and trommels with slots of 0.25 inch diameter, the over-size passing through finer rolls. The whole product from the rolls goes to Ball-Norton separator delivering 3 products, samples of which, taken by the writer, show as follows:—

(1) Tails	carrying	7.08	p. c. iron.
(2) Middles	"	48.03	"
(3) Heads	"	63.40	"

The heads are delivered to ore cars going directly to the smelter. The middles are re-crushed by finer rolls and re-treated. The waste rock, worth 25 cents a ton at the mine, is sold for concrete and building purposes. At this mine there is also in operation a magnetic cobber, built by Mr. C. M. Ball, which cobs the ore classed as run of mine. The ore is fed from the skips to large jaw crushers, through trommels with slots of 2.5 inch diameter and to the cobber consisting of a cylindrical magnetized drum around which an inclined belt travels. The crushed ore, consisting of coarse and fines, falling on the belt is divided into non-magnetic tails, falling directly down past the end of the drum to cross travelling belts leading to the waste piles. The magnetic particles cling to the belt till they reach the lowest point of the cylinder where the magnetism ceases, and fall on cross conveying belts leading to ore cars. Samples from the magnetic cobber taken by the writer show thus:

HEADS.	IRON P. C.
Coarse ore—2.5 inch diameter	43.87
Fine ore—	53.43
TAILS.	
Coarse rock—2.5 inch diameter	6.82
Fine rock—	13.45

The scheme for cobbing may be shown by diagram thus:

Run of Mine
↓
Jaw crusher
↓
Trommel (2.5″ slots) — → over-size
↓ ↓
← ———————— Rolls
Magnetic
Cobber
↓ Non-Magnetic falls to waste piles.
↓ Magnetic Heads to Smelter.

The Ball-Norton separators have been used for some years at the Chateaugay Mines in northern New York where about 12,000 tons are being treated per month. The ore at this mine carries only 38 p. c. iron, is diffiicult to mine, while the smelter is some distance away, so that costs run up considerably. The one saving condition is that the concentrated ore is uniformly high grade, running 66 p. c. iron. Several water concentration systems have been tried, including Hartz jigs, and found to be of little use, as about ⅓ of the ore was lost in treatment producing 1 ton of shipping ore from 3 tons of crude; also hydraulic classifiers giving no better results.

Magnetic concentration proved successful from the start, and there are now installed 10 Ball-Norton separators, producing 1 ton of concentrates carrying 66 p. c. iron from 2 tons of crude ore carrying 38 p. c. iron, which is crushed and sized to 0.25 inch for treatment. This separator has also given successful results at Benson Mines, Mineville, Arnold Hill and Ferronia in New York State, also at Svarto Mine in Sweden.

The Buchanan separator originally consists of double rolls revolving in opposite directions and forming the ends of a horse-shoe magnet as in Plate XIV. The ore entering at the top is divided into tailings falling vertically while the magnetic concentrates are deflected as in the photograph.

An improved form is used for coarser material about 0.5″ diameter as shown in Plate XV. The magnetic fields are on each side of the drum. The large drum is rotated to the left, carrying ore fed on the right side upwards against gravity and centrifugal force.

The magnetic particles clinging to the ascending surface are carried over the top and pass a second magnet holding the magnetic particles, here they reach the bottom of the drum while the non-magnetic fall vertically.

The rich tailings falling on the right side of the drum are passed to a smaller drum of intense magnetic power separating non-magnetic material from the magnetic in a similar way as the large drum. The Buchanan separator has been used at Hibernia mines, in New Jersey, Croton mines in New York State, Michigamme mine in Michigan, etc.

The Wenstrom separator is a single cylinder with alternating strips of magnetic and non-magnetic material forming the periphery, as may be seen in Plate XVI. The ore falling on the travelling belt comes in contact with magnetized periphery holding the magnetic part of the ore while the non-magnetic fall vertically. The ore travels underneath the cylinder till it meets a demagnetized portion where it falls as shown in the cut.

This separator has met with long continued success in Sweden, being first installed at Hjuljern in 1885, and has been used at Grangesberg, Dannemora, Lulea, etc. In America it has been used at Mineville, Cranberry Lake, Michigamme and elsewhere.

The Heberli separator as shown in Plate XVII, is in use in Germany for treating complex magnetic ores. The crushed ore enters at A with a stream of water, and the non-magnetic particles fall vertically through a column of water into E, and pass out at F.

The magnetic particles are attracted by the magnet M, and fall down into C, passing out at D. An endless travelling belt carries magnetic particles past the magnet.

The Heberli has not been yet introduced into American mines.

The Edison separator is essentially a stationary magnet past which the ore falls by gravity from a hopper as shown in Plate XVIII. The magnetic particles are deflected, separating them from the non-magnetic which fall vertically into separate receptacles. The writer recently visited the mines near Edison, New Jersey, where a plant was in operation in 1897 on an immense scale, but found the plant dismantled, although accurate information regarding the method of concentration was obtained.

The problem which the inventor, Mr. T. A. Edison, undertook to solve was the enormous one of quarrying rock carrying 25 p.c. magnetite, crushing it fine, separating magnetically the particles of magnetite from the ore by air blast, forming the clean pulverized ore into solid briquettes, loading and shipping the product to local furnaces, at cost below that at which Lake Superior ores could be delivered at the same furnaces, in order to enable them to compete with the Pittsburgh furnaces.

The ore body may be classed as country rock. It was quarried by blasting 2 inch holes 8 feet apart, 20 feet deep and 12 feet back from the working face.

The crude ore, thrown out in blocks often weighing 5 tons, was loaded by a steam shovel to skips dumping into giant rolls 6 feet in diameter and 6 feet face, crushing the ore which was passed to 3 sucessively finer rolls, delivering ore crushed to 0.50″ size and finer, which was elevated to a vertical dryer 9 feet square and 50 feet high having alternate shelves of cast iron tilted at 45° downwards.

The dried ore was elevated to a stock house and conveyed to rolls and screens of about 0.10″ size of holes, the over-size returning to the rolls while the fines were allowed to fall past a series of horizontal magnets deflecting magnetic particles carrying 40 p.c. iron and allowing the tailings to fall vertically into conveyors leading to waste heaps. The concentrates were dried, crushed to about 0.05″ size and treated by a second series of magnets delivering concentrates carrying 60 p.c. iron which were subjected to an air blast, removing apatite as a finer dust, and passed to a third series of magnets, making a final concentrates of Bessemer grade carrying 68 p.c. iron and tailings, which were re-ground and returned to separator. The final concentrates were mixed in cylindrical machines with rosin soap and compressed into briquettes 3" by 1.5" which were heated in drying ovens to 600° F to render them waterproof, hard to endure handling, porous to enable furnace gases to penetrate, and non-friable to resist the action in the blast furnace.

The capacity of the plant was 300 tons of rock per day, one-quarter of which was made into briquettes, the remainder being sold for building purposes.

The system was a marvel of engineering skill, automatic from start to finish, but was not continued,as it did not prove profitable. A draw-back was the friability of the briquettes in the blast furnace. Local iron men appeared to be satisfied that the operation would be profitable if the price of Lake Superior ores should rise 75 cents a ton.

It is proposed to use the Edison system on low grade Norwegian ore owned by the Dunderland Iron Ore Co. shipping the concentrates to English furnaces.

The Grondal-Delwik separator is adapted to finely crushed ore employing water as a means of cleaning dust from the ore.

Plate XIX shows a diagram section. The ore enters at N, together with water from N to L and passes along side the cast iron drum A B, which has coils of copper wire carrying electric current so that magnetic particles are held to the iron rings while non-magnetic particles are washed down into P.

The wooden drum C C revolving 3 times faster than A B has steel pegs on its periphery which become magnets by induction, causing particles to hop across, carrying them around to the demagnetized portion where they are worked down by water from K.

This separator has been working since 1894 at Pitkaranta, Finland, treating a low grade magnetite carrying 25 p. c. iron mixed with chalcopyrite and zinc blende.

The Blake-Morscher system of ore-dressing by static electricity is the recent invention of Prof. L. J. Blake, of the University of Kansas, and is said to have met with success in treating zinc-lead ores at the Colorado Zinc Works, Denver, Colorado.

The method consists in bringing a mass of ore particles into contact with a statically charged metallic surface, such materials as pass conductivity are instantly repelled, while those of low conductivity are not so rapidly repelled, allowing them to be pulled out of the path and caught in a separate receptacle.

It is said to work well on iron ores.

USE OF FINELY DIVIDED ORE IN THE BLAST FURNACE.

An argument often brought forward against concentration of iron ores is that the concentrated product is too fine for use in the blast furnace. The writer visited many smelters and has ascertained that the present practice favors the use of finely divided ores, as it is cheaper to smelt the fine ore.

Of course any ore less than 0.10″ diameter should be briquetted, but concentration methods generally avoid crushing finer than this size owing to greater cost, so that concentrated ore is generally acceptable at the furnace.

OPPORTUNITY IN CANADA FOR CONCENTRATION OF IRON ORES.

The writer is at present making experimental investigation of different Canadian ores and regrets that the matter is not yet ready for publication. This paper is only a preliminary study of the present practice and if any new points have been brought forward of benefit to Canadian mining men, the writer will be satisfied.

In general it may be said that magnetic concentration can only be profitable where local conditions favor it, such as cheap labor, lack of competition with naturally rich ores, cheap power, etc.

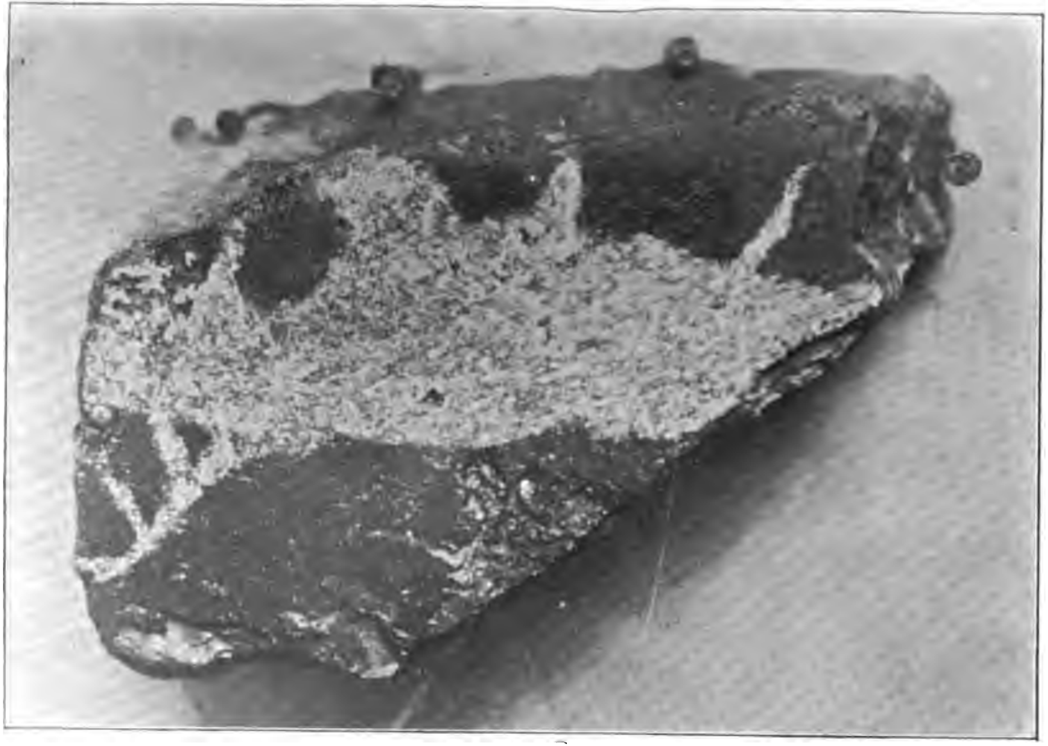


Plate I.—Shows an Iron Ore with Magnetite (coloured black) and Siliceous Rock (coloured white) very coarse grained. This Ore is amenable to Coarse Concentration.

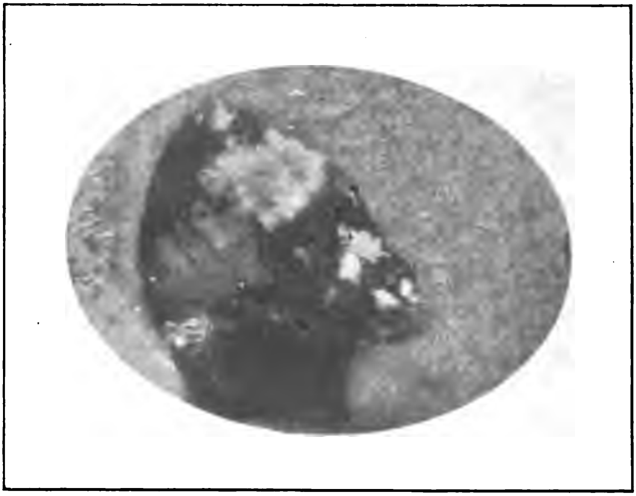


Plate II.—Shows an Ore amenable to Coarse Concentration owing to segregations of the Magnetite (black) being coarse.

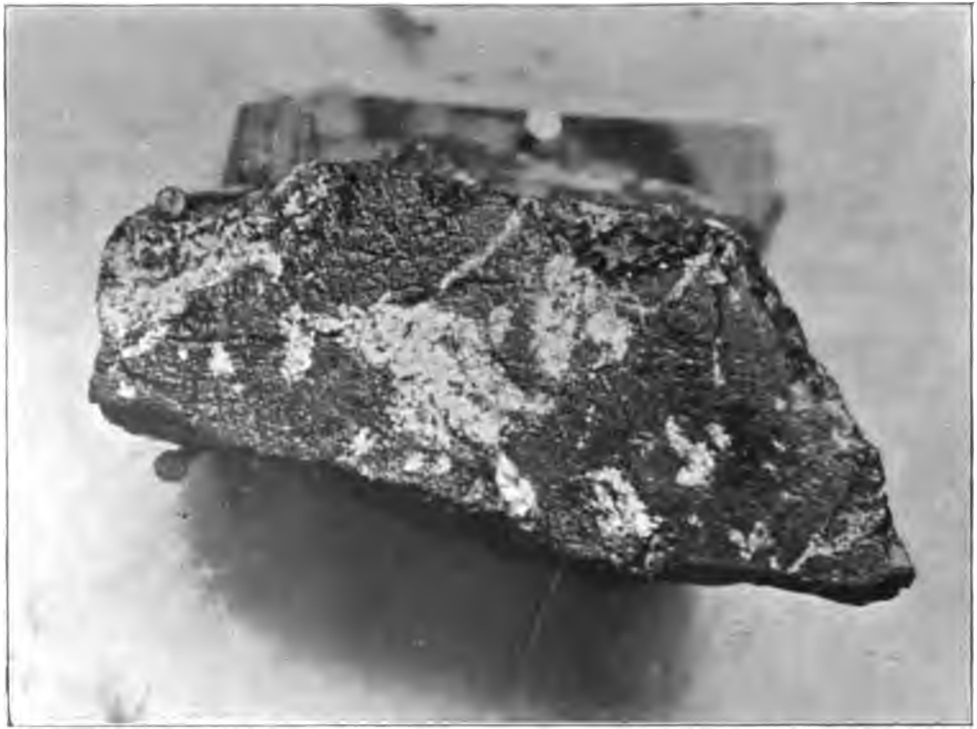


PLATE III.—Photo showing an Ore adapted to Medium Coarse Concentration.

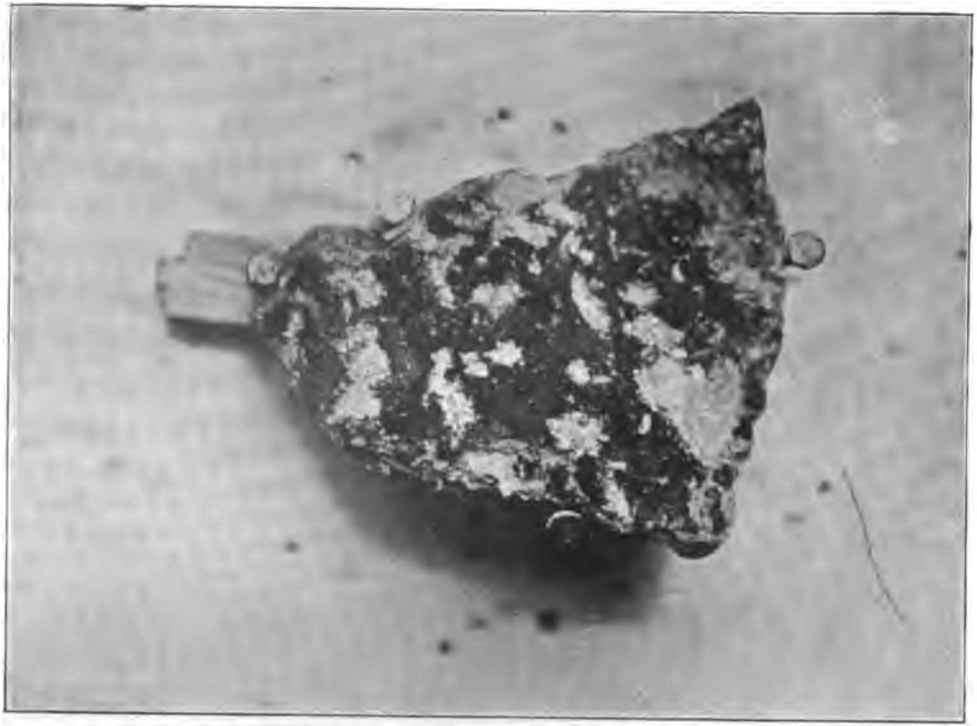


PLATE IV.—Showing an Ore amenable to Medium Coarse Concentration. The black is Magnetite. White is Actinolite.

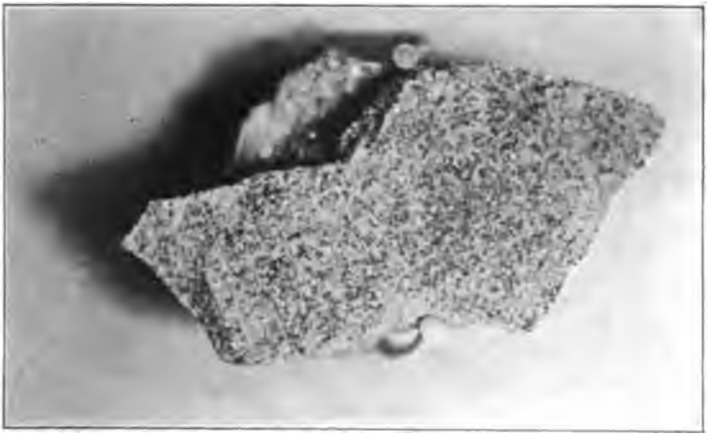


Plate V.—Showing an Ore having no value for concentration owing to fine grained ore intermixed too closely with rock. Black is ore. White is rock.

MAGNETIC CONCENTRATION OF IRON ORE.

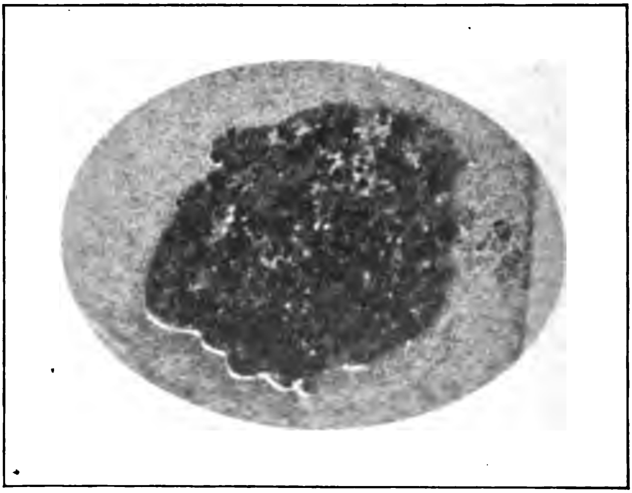


PLATE VI.—Shows an Ore of no value owing to fine grain of the ore intermixed with rock. Black is ore. White is rock.

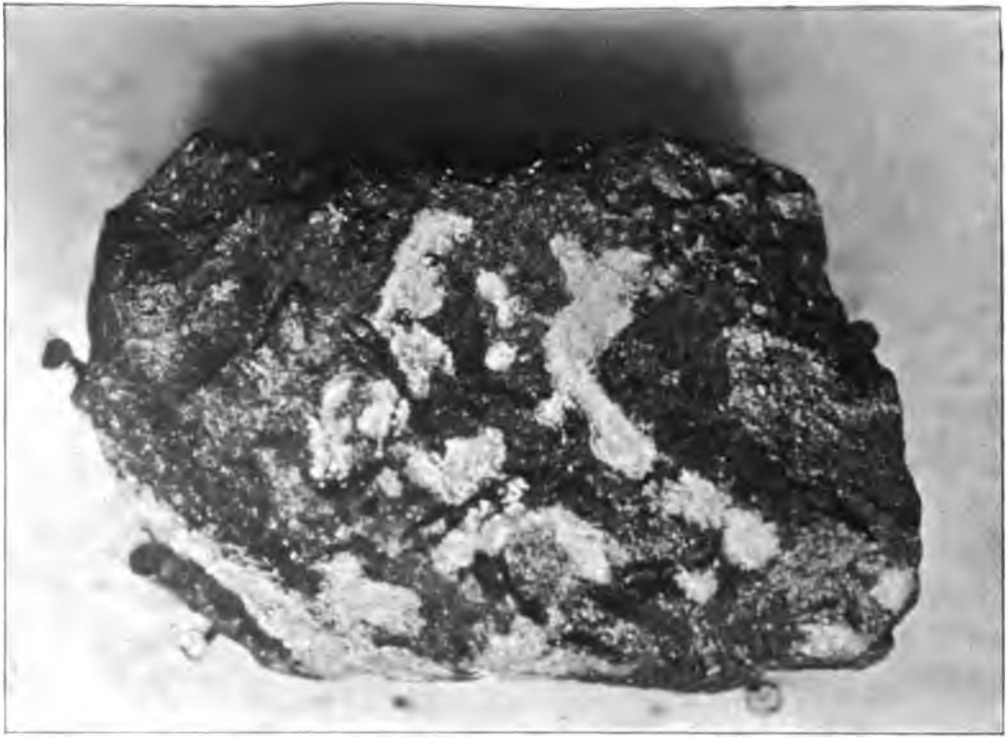


Plate VII.—Shows Pyrite (light colour) in segregated masses of Magnetite (black) and hence the pyrite can be separated out by coarse crushing.

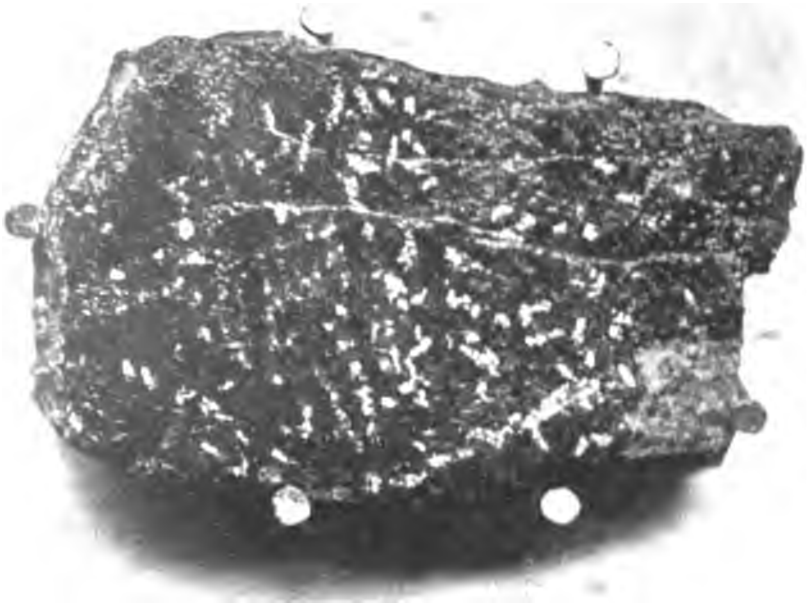


PLATE VIII.—Shows fine grained Pyrite (light colour) interspersed with Magnetite (black). This ore requires very fine crushing in order to detach the pyrite from the magnetite.

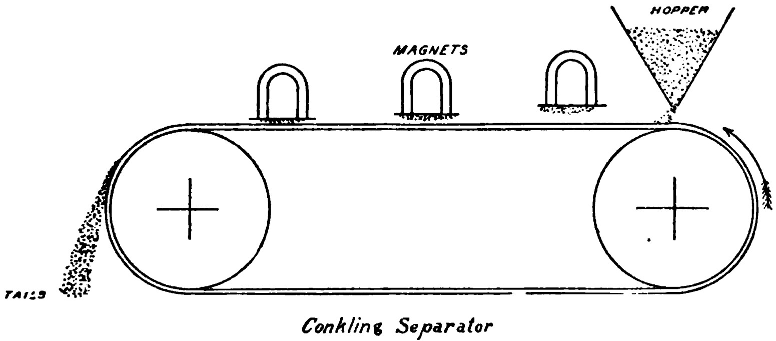


PLATE IX.—Conkling Magnetic Separator.

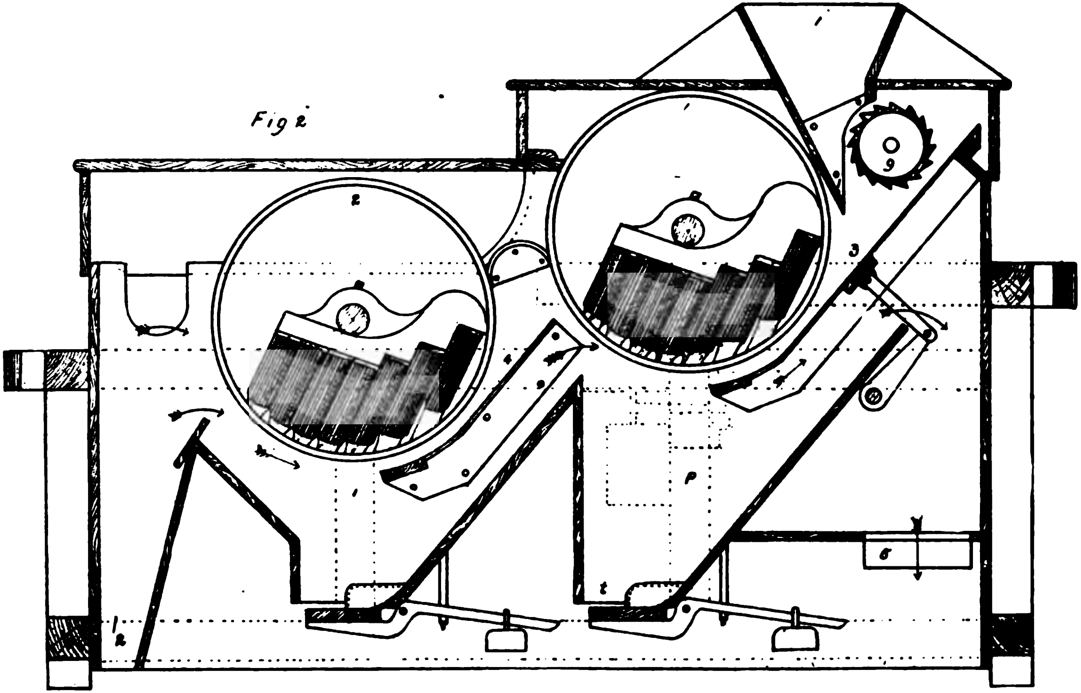


PLATE X.—Diagram of Ball-Norton Three-Part Magnetic Separator.

Plate XI.—Reprint from photo at the Hibernia mines, New Jersey, showing Stock House, Crushing and Separating Plant. Ore enters at left passing out at right.

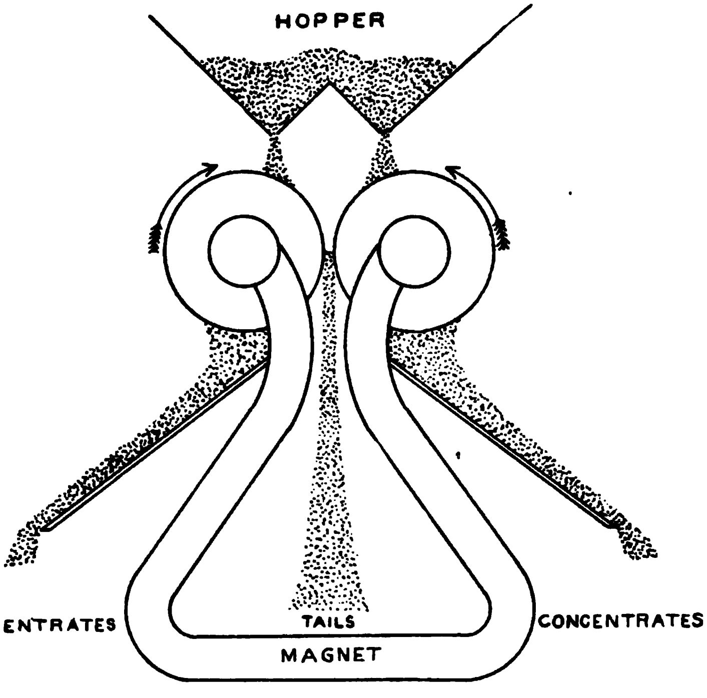


PLATE XII.—Diagram of the Buchanan Separator for Zinc Ores.

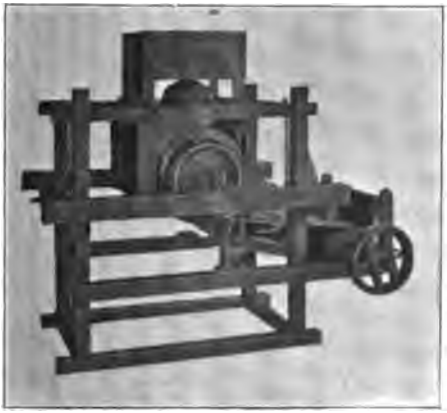


Plate XIII.—Buchanan Separator for Coarse Ores.

MAGNETIC CONCENTRATION OF IRON ORE.

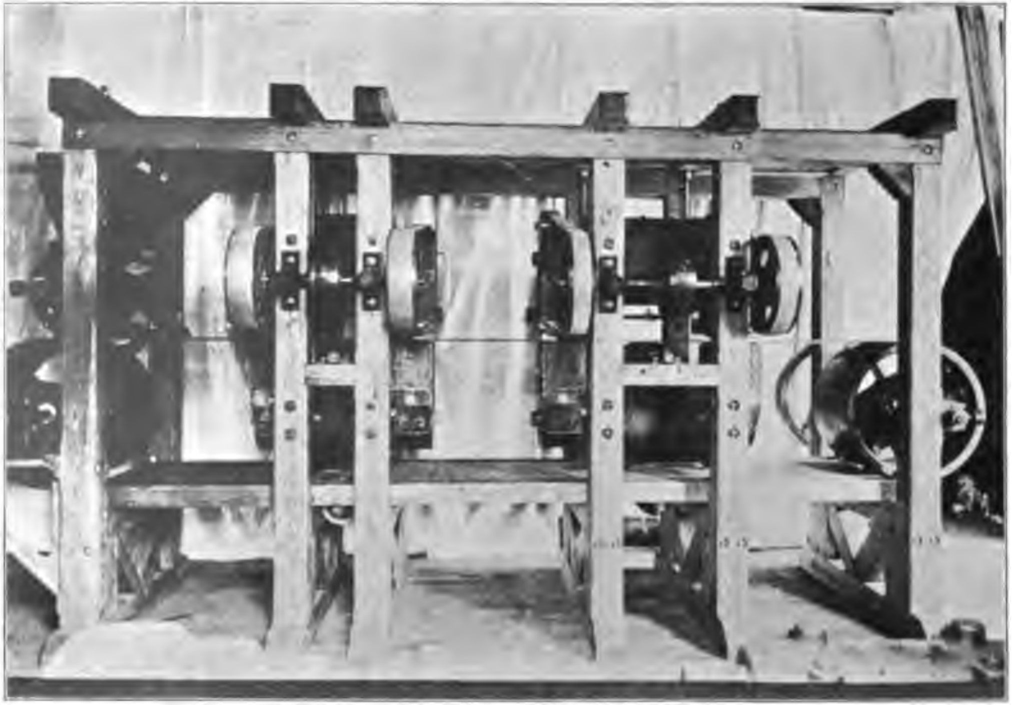


PLATE XIV.—Wetherill Separator for removing Mica and Hornblende as a magnetic product from Apatite.

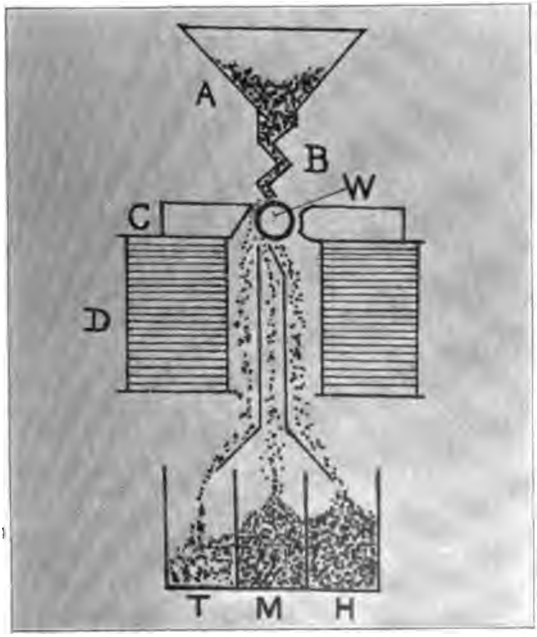


Plate XV.—Diagram of the Rowand type of Magnetic Separator made by Wetherill Separating Company for use on Magnetic Iron Ores.

A—Hopper for Ore.
B—Zig-zig delivery spout to shake up ore.
W—Revolving Drum.
C—Magnetic Pole.
D—Horse-slide Magnet.
A —Magnetic Heads.
M—Middles.
T—Non-magnetic Tails.

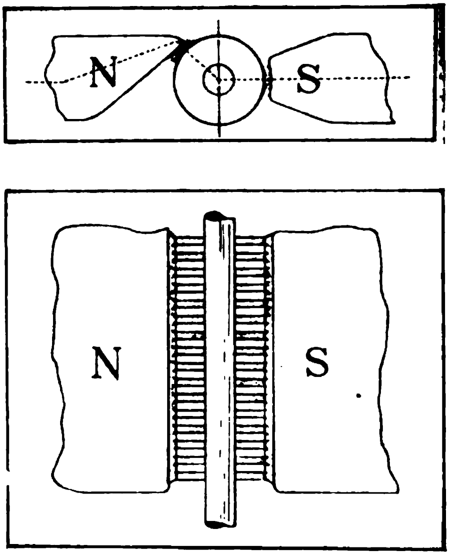
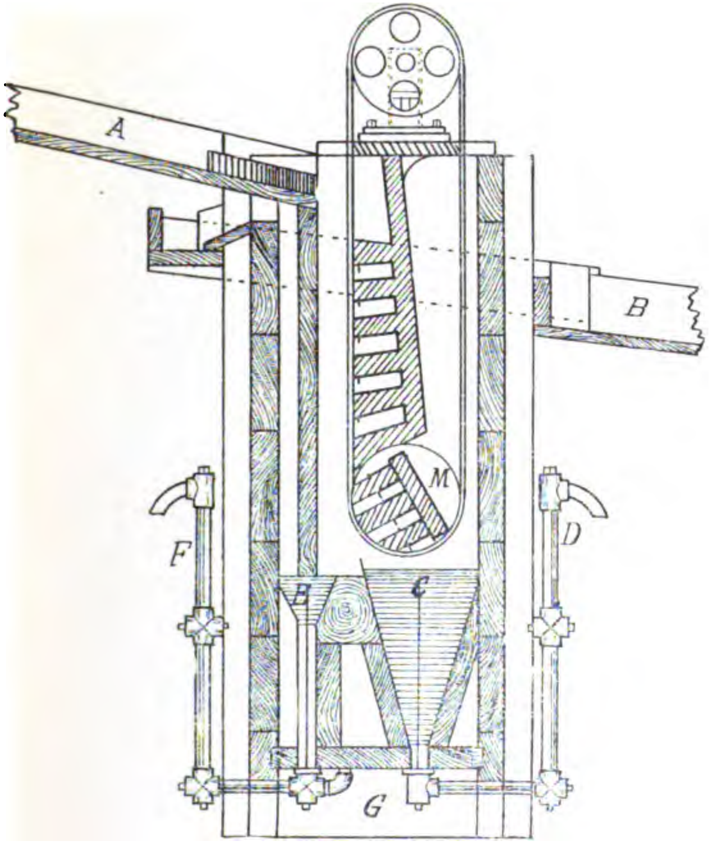


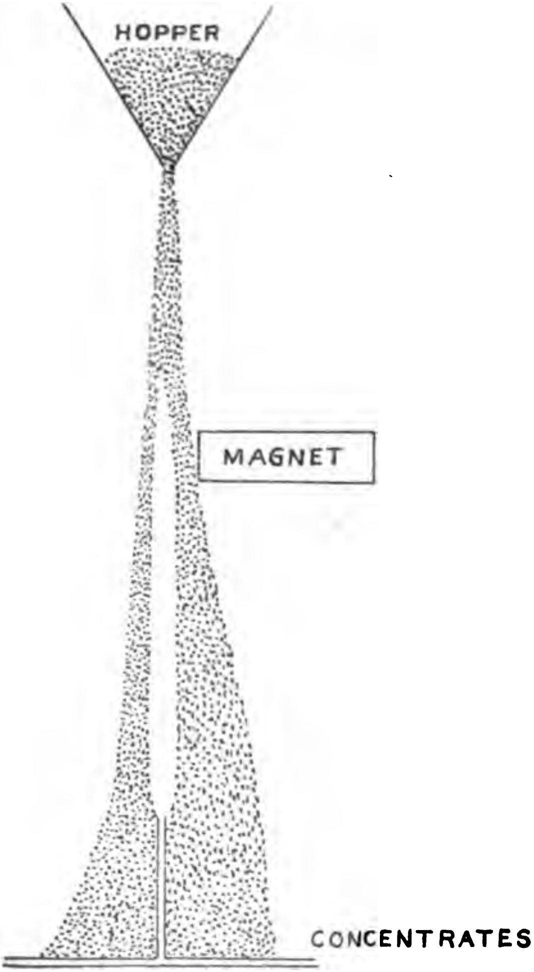
PLATE XVI.—Diagram after F. A. Schnelle, showing the concentration of magnetic force at the end of Pole N ; also the alternate bands of magnetic and non-magnetic material making up the roller or drum and forming local concentration as shown by induction.

PLATE XVII.



HEBERLI SEPARATOR FOR ROASTED IRON ORE
MAGNETITE ORES

PLATE XVIII.



EDISON SEPARATOR

MAGNETIC CONCENTRATION OF IRON ORE.

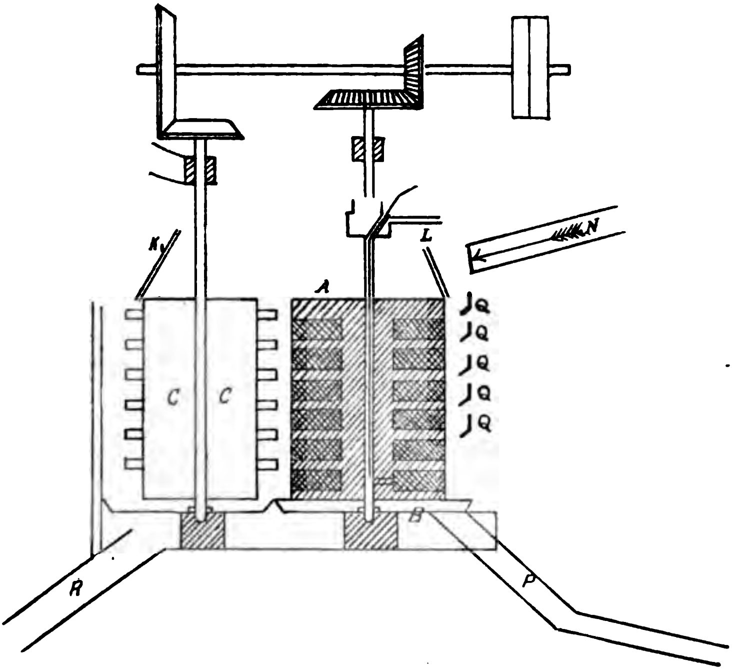


PLATE XIX.—Grondall-Delvill Magnetic Separator.

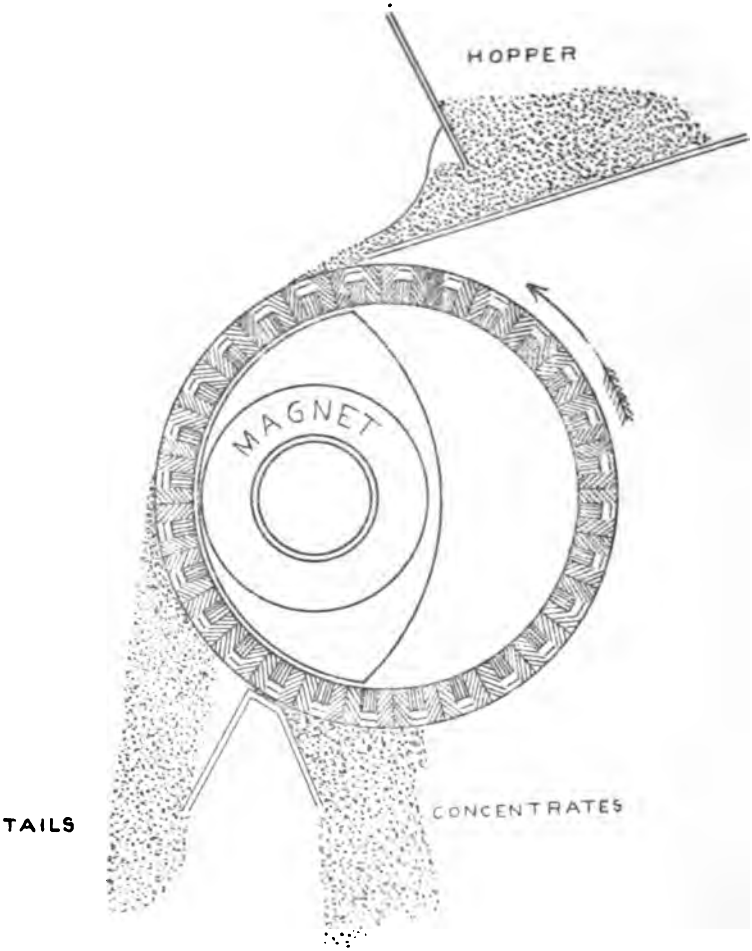


PLATE XX —The Wenstrom Magnetic Separator.

Notes on the History of the Mineral Industry in the Nineteenth Century.

By WILLET G. MILLER, Toronto, Ont.

On reading an interesting review of the progress of the mineral industry in the nineteenth century, written a year or two ago by Prof. Treptow, of Freiberg, it occured to me that the subject would be a good one to bring before the members of this Institute** A knowledge of the wonderful progress which has been made in our industry in the last century should afford us encouragement for the future.

Prof. Treptow is a member of the staff of the Freiberg School of Mines, an institution which has itself played a very important part in the great advancement which has been made in mining and metallurgical methods during the last hundred years. This technical school has also, we might say, had much to do with the immense increase which the last century has witnessed in the volume of mineral products, its graduates having been pioneers in almost every great mining country of the world.

Prof. Treptow's paper gives a handy summary of the statistics of some of the most important mineral substances, together with a sketch of the early utilization of minerals which first came into commerce in the century just closed.

In the following notes I have summarized Prof. Treptow's paper, and have taken the liberty of rearranging some of the material and adding a few notes so as to make it more applicable to this side of the Atlantic..

The history of mining, or in a wider sense the mineral industry, in the 19th century is characterized by a great advancement in technology and a corresponding enormous increase in production over earlier times. There has also been a great widening of geographical boundaries. As a result of the period of great geographical discoveries

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**Die Geschichte des Bergbaus im 19. Jahrhundert. Vortrag gehalten vor der Naturforschenden Gesellchaft in Danzig von E Treptow, Professor an der Königl. Sächs. Bergakademie zu Freiberg i S. Mit 1 karte und 3 Tabellen. Freiberg 1901.

in the 16th century practically only Mexico and a part of South America were added to the list of mining countries. In the 19th century North America, a great part of Asia, Australia, and finally South Africa became great centres of mining activity and eclipsed in production the older countries.

In the 19th century the industry has done much to promote the cause of civilization, and has opened up many remote and previously little known parts of the earth. In this connection it is only necessary to mention the great effects which have resulted from the rush of gold diggers to California in the late 40's and to Australia in the early 50's.

Mining has been wonderfully influenced by the progress which metallurgy and the chemical industry have made in this century. The development of the science of chemistry, which can hardly be said to have existed at the end of the 18th century, has greatly enlarged the use of previously known economic minerals and has also found uses for many others which, though known, were of no commercial importance.

THE PROGRESS IN TECHNOLOGY OF MINING.

Only the chief points in the progress of mining technology can be briefly referred to in the space at our command. The sciences of mineralogy, geology and ore deposits on the one hand and mining on the other have had a closely interwoven history. Even after the former had become distinct sciences they have profited from observations made by miners and from the opportunities which have been provided by mining operations for examining beneath the surface of the earth. Mining has also, it is unnecessary to say, been put under deep obligation for assistance received from these sciences.

Somewhat different is the relationship between mining and the construction of machinery. In the 18th century, and in some places still longer, the miner built his own machines, his whims, water wheels and other structures used in the art of the times. The widening use of steam gradually divorced the work of the miner from that of the machinist until at the present time while the mine manager may have something to say about the design of a machine its construction is left to others.

The advance to be made in the industry in the future, especially in deep mining, will depend not so much on the miner as on the mechanical engineer. This is seen in connection with the deep shafts which have been sunk, *e.g.*, in Michigan and in South Africa

Steam machines of the earlier part of the century have been naturally largely superseded in deep mining by those using compressed air, in which great advances have been made in late years. Electricity is also beginning to play an important role in the operation of pumps and for other purposes in connection with mining.

Then there were the invention of the diamond drill in 1864, and development of the methods for obtaining oil and gas, the improvement in pumps, introduction of the use of nitro-glycerine as an explosive in 1862, the safety lamp for use in coal mines, 1815, and the improved methods of mine lighting in general. All of these inventions and improvements have made a wonderful change in the industry.

The advancement which has been made in ore-dressing machines since about 1850 is also of great significance.

Further, the perfection of metallurgical processes has made it possible to handle ores of so low a grade at a profit that workers in earlier centuries could not have been convinced of the possibility.

INCREASED PRODUCTION IN OLDER MINING OUTPUT.

Gold is the most widely prized mining product, and then follow iron, steel, and coal. The increase in production of these materials illustrates pretty well the advancement which has taken place in the whole industry. The production of these substances at the present time as compared with that of the last century shows also the great widening of geographical boundaries which has taken place. The three products which form the basis of all commerce show a striking difference in value. While 1 kg. of gold in the world's market has a fixed value of about $700, 1 kg. of iron at the place of production is worth something like 2½ cents, and 1 kg. coal about ¼ cent. The high value of gold permits its mining over all parts of the earth. Gold mining withstands the difficulties of every climate and unfavourable geographical situation. While the production of iron and the winning of coal can only be carried on successfully on a large scale, they are dependent on trade conditions.

The changes which have taken place in gold production during the last hundred years, as regards quantity and origin, are shown in the accompanying table. It is compiled from the works of the well-known statisticians, Soetbeer (1800-1875), Hauchecorne (1880-1890), and Rothwell. Only those time periods are given in the table which indicate a striking change in production, and only the larger producers among the countries. Whole numbers give yearly production in kilogrammes; in the first part of the table the average of ten years, then every five years, and finally in more recent times the individual years are given. The order of the countries in the table is based on amount of production.

In the first decade of the century Austria-Hungary was the only country in Europe which produced an important amount of gold This was derived chiefly from the well-known mines of Hungary and Siebenburgen. A little also came from the old gold district of Bohemia and other localities. The production of Austria-Hungary has increased quite gradually in the course of the century.

The production of Africa in the earlier years is estimated. In the first part of the century gold came only from the Niger country and reached Europe by caravans to the Mediterranean. In later times Rhodesia has also produced gold. The centre of production in these early years lay in Central and South America—Mexico, Columbia, Brazil, Peru, Bolivia, Chili, affording about 75 per cent. of the output in the first decade.

In Genmany the production in the early part of the century was so small that it is not given separately. Gold ores do not occur in important quantity, the metal that is produced in that country occurring in small amounts in association with copper pyrites and other minerals, and being obtained through smelting these ores. Considerable gold is however produced from imported ore and from the refining of what may be called scrap gold.

In the second decade an important decrease took place in the noble metal production of Spanish America, as a result of political dis-

Table I.

GOLD PRODUCTION IN THE 19TH CENTURY.

(The yearly production is given in kilograme. One kilogram=32·1507 Troy ounces).

—	1801-10	1821-30	1841-50	1851-55	1856-60	1871-75	1885	1890	1895	1898	1899	1900	Remarks
Transvaal......	......	......	......	....	....	......	....	15,318	63,589	117.470	109,783	10.300	S. African War, 1899
United States......	....	110	17,600	88,800	77.100	59,500	47,848	49,421	70.470	97.933	105,471	118,362	Cripple Creek, 1891
Australia	......	....	....	67,700	86.700	59,900	41.287	44,851	64,473	93 732	119,186	113,282	West Australia, 1889
Canada......	......	....	....	....	....	....	1,679	2.506	2,876	20,614	31,675	39.121	Klondike, 1896
Russia with Siberia......	165	3,375	22.515	24,730	26,570	33,380	38,125	38 345	51,161	37,217	36,056	34.744	
British India......	....	....	....	....	....	....	203	3,009	6,786	11,685	12,618	14.098	
Mexico......	1,763	976	1,994	2,010	1,358	2,020	1,304	1,154	8,427	12,393	13,960	12,589	Note—The reason for not giving in this table the production of some countries in the earlier part of the century, is due, in some cases, to lack of statistics, and not on account of there being no production. In the case of other countries, e. g. Canada, the statistics have little value for the purpose of the table.
China......	....	....	....	....	....	....	6,997	8,020	6,998	9,993	10,000	8,276	
Guiana......	....	..	....	....	....	....	......	3,186	5,530	5,739	6,697	6,112	
Columbia......	5,000	3,200	3,400	3,500	3,500	3,500	3.762	5,416	4,890	5,567	5,116	4,213	
Africa, excepting Transval......	1,200	1,200	1,500	1,500	1,500	3,000	2,083	2,000	2,232	2.338	2,922	2,428	
Austria-Hungary.	960	1,135	1,950	1,775	1,560	1,395	1,774	2.104	2,753	3,136	2,839	3.073	
Germany......	....	....	....	....	....	....	1,378	2,000	4,335	2,847	2,605	3,054	
Brazil......	3,750	2,200	2,400	2,200	2,120	1,720	204	670	3.359	3,809	2,383	2,408	
Venezuela......	....	....	....	....	....	....	7,033	2,372	1,281	1,225	1,450	1,530	
Peru, Bolivia, Chili	4,890	1,920	2.200	1,800	1,650	2,760	835	2,367	1,383	2,928	3,207	3,394	
Other Countries..	50	100	1,200	3,500	4,000	3,500	653	2,796	3,482	6,450	7.060	16,904	
Total......	17,778	14,216	54,759	197,515	206,058	170 675	155,165	185,675	305,025	435,076	473 028	393,888	

turbance caused by the separation of the individual states from the mother country.

The first large Russian output of over 3000 kg. yearly is due to the beginning of mining in the Urals, from the year 1820. A decade later the western Siberia gold mines began operations. If we follow the Russian production still further we find that in the fifth decade there is a sudden rise to 22,500 kg., and in the year 1895 the output has gone up to 50,000 kg. These increases were due to the finding of easily worked alluvial deposits. The decrease at the end of the century is due to influences connected with the building of the Siberian railway.

At the end of the first half of the century came in two wholly new gold producers, California and Australia. In the year 1848 alluvial gold in great quantities was found in the former country. A gold fever such as up to that time the world had not known affected not only North America, but made itself felt much more widely, and a rush was made westward to the little known domain. Shortly after, in the year 1851, the first gold discoveries were made in New South Wales and Victoria, Australia, and some years later in Queensland and New Zealand. It was owing to these easily worked alluvial deposits that the world's production in the 50's reached a point which had never before been attained and which was not equalled for many years afterwards. North America and Australia remian from that time for four decades at the top of gold producers.

The discovery of the Comstock lode in Nevada in 1858, the greatest of its kind known, and the celebrated Mount Morgan in Queensland, discovered in 1873, and Bendigo in Victoria gave an impetus to lode mining. Up to 1890 the Comstock lode produced something like $150,000,000 in gold and $200,000,000 in silver, and mining had then reached a depth of 1005 m. or about 3,300 feet.

If we now glance at the year 1885, we see that the table gives the production of Germany, China and Venezuela separately for the first time. British India and Canada are also similarly treated, and it is seen that the production in Central and South America has noticeably shrunken.

In the last ten years of the century the gold production has materially changed. Especially is one stuck with the totals, which differ so greatly in this decade from the preceding four decades.

The increased production during this decade was brought about through the discovery of the celebrated South African deposits at at Johannesburg in 1888, whose output has grown with such surprising rapidity. The Transvaal is the first country which reached an output of 100,000 kg. Along with this comes the discovery of the West Australian gold fields in 1889, the most important districts being Coolgardie and Kalgoorli. Through these Australia reached a second maximum of production, the first being about 40 years earlier. Finally are to be noticed the discovery of the Cripple Creek gold field in 1891, and the beginning of the operations in the Yukon in 1896. Canada through this last took her place as a gold producing country of the second order. The United States in 1899, for the first time, had an output of over 100,000 kg.

The total gold production of 1899 had a value of $331,000,000, or 1,324,000,000 M., which, however, would occupy a space of only 25 cubic metres.

Acccording to Soetbeer, the total yearly production in the three preceding centuries fluctuated as follows:—

16th century,	between	6,000	and	8,500 kg.
17th "	"	8,300	"	10,600 "
18th "	"	12,800	"	24,600 "

The chief causes contributing to the wonderful increase in production in the 19th century are the discovery of large alluvial deposits, together with the developments which have taken place in milling, smelting, and chemical processes. While smelting could be earlier applied to refractory ores, modern chemistry has added other methods of treatment. In 1848 Plattner discovered the chlorination process, and in 1888 Forrest added the cyanide process to the treatment of such ores. While in the first half of the century the chief gold produced was obtained from alluvial diggings, the end of the century witnessed the eclipsing of the product of this method of working by the output from lode mining.

It may be added that the second quarter of the century also witnessed the perfecting of the methods of separating gold from other metals, silver, copper and lead. Many old silver and copper coins held so much gold that it paid to separate it.

IRON.

We shall now take up a consideration of the iron production in the century just closed. Table II gives the amount for the beginning, the middle and the end of the century. The numbers for the years 1807 and 1854 are taken from "The History of Iron," by Dr. Ludwig Beck, 4th ed., 1899. The figures for 1900 are taken from Rothwell's "Mineral Industry."

The increase in the production of iron in the course of the century is at least as striking as that of gold. The increase in the output of the latter metal is thirty-fold, while the production of the former is now ninety times as great as it was at the beginning of the century. In the early part of the century the production of Great Britain and France exceeded that of all other countries. Then followed in order Russia, Sweden, and Austria-Hungary. Germany occupied the sixth place and was followed by the United States. In the comparison of the production of France and Germany in 1807, it should be remembered that at that time the latter country embraced a much less extensive territory than in later times, while the former included the output of Holland, Belgium and other territory. Great Britain stood far in advance of all other countries at that time in the production of the metal. The explanation is that the evolution of the steam engine took place in that kingdom, and the smelting of iron by means of coal, which had already begun to replace charcoal, placed this country in the van till after the middle of the century. The development of the railway in Great Britain, after Stephenson had shown his steam waggon in 1829, also increased the country's interest in the production of iron. The birth of these inventions in the island kingdom affords an adequate explanation as to why at the middle of the century she produced two-thirds of the total coal output of the world.

On the continent at the end of the 18th century attempts at smelting iron with coal had been made only in Upper Silesia. In all other districts smelting was confined to charcoal, almost to the end of the first quarter of the century and in many places till much later. Then the higher cost of wood and in many places the lack of it, together with the tendency towards the use of coke, brought about a change in the industry, the relative standing of such countries as Sweden and Spain where coal is wanting being greatly altered. A highly developed iron industry is to-day only possible where iron ore and coal occur in large quantities near each other or where, as in the United States, the means of transportation are exceptionally well developed. The production at the present time is also successful only where the material can be turned out in very large quantities, and where there is a corresponding large market near at hand.

Brief reference may be made to inventions which have contributed much to the great increase in production of the metal, such as air heating and the evolution of the present type of furnaces; the use of rolling mills and steam hammers in place of hand labor; the Bessemer process, invented in 1856, and that of Gilchrist and Thomas in 1879, through which come the direct production of steel in large quantities

TABLE II.

PRODUCTION OF IRON AND STEEL IN 1,000 METRIC TONS.

	1807		1854		1899				1900	
	Iron	Per Cent.	Iron	Per Cent.	Iron	Steel	Iron and Steel	Per Cent.	Iron	Steel
United States....	24	3·	1,000	17	13,839	10,737	24,576	36·5	14,009	10,382
Great Britain....	250	33·	3,000	52·	9,454	4.933	14,387	21·	9,003	5.130
Germany	35	4·6	257	4·5	8,029	6,290	14,319	21·	7.549	6,645
France...........	22·5	30·	600	10·	2,567	1,529	4,096	6·	2,714	1,565
Russia	84	11·	200	3·5	2,600	1,400	4.000	6·	2,895	1,830
Austria-Hungary	50	6·6	225	4·	1,300	660	1,960	3·	1,311	1,145
Belgium	......	......	300	5·	1,036	730	1,766	3·	1,161	655
Sweden..........	75	10·	155	2·7	524	258	782	1·	526	300
Other Countries	16	1·8	80	1·3	1,052	583	1,635	2·5	625	400
Total	759	100·	5,817	100·	40,401	27,120	67,521	100·	39,793	28,052

and the making possible of the use of iron rich in phosphorus; the use of aluminum in iron castings, and the alloys of manganese, chromium, tugsten, nickel and molybdenum. The iron industry owes in the case of these alloys very much to modern chemistry.

The last space of the table shows the present situation of the iron and steel industry in various countries. The United States stands easily in the first place. In the second class, together, are Great Britain and Germany. Then follow at a considerable distance France and Russia; then Austria-Hungary and Belgium, and finally Sweden. It is clearly seen that the iron industry reaches large proportions only in North America and Europe. The whole of South America, Africa and Australia possess no modern furnaces; only in Asia has the modern industry begun to take a solid footing. Through the building of the Siberian railway some of the older iron works, *e.g.*, Petrowsk in the Trans-Balkans, which has been established about 100 years, have begun to take on new life. China has had for some years a steel works at Hanyang, and Japan has a similar works which was recently completed in the vicinity of the port of Wakamatsu. There is also a native iron industry in the Himalayas, in Japan, in many parts of Africa, *e.g.*, in German Togo, but the quantity of iron produced in these districts is insignificant.

COAL.

The coal industry is in a similar position to that of iron, since it depends not only on the occurrence of the material, but also on the market for it. Table III gives the situation at a glance. It may be stated that brown coal is produced in important quantities only in Germany and Austria-Hungary.

The development of the coal industry in the 19th century can be briefly described as follows:—At the beginning of the century it had the standing of a great industry only in Great Britain, in the districts of Durham and Northumberland, which are at the present day important centres of the industry in the island kingdom. The yearly output at that time was from two to three million English tons (1 Eng. ton= 1016 kg.) On the continent there was in many places a coal mining industry, but the consumption was very small and was confined to the areas immediately surrounding the workings, since the means of transportation was limited. In Germany the industry first became prominent about 1840, and in the United States about 1850. Great Britain in the middle of the century was even a greater leader in coal production than in that of iron. The result was due not only to the demand for coal in the industries of that country but was owing to the situation of the coal fields, either near the sea or on navigable rivers, which favored the export of large quantities of the material.

TABLE III.*

COAL PRODUCTION IN 1,000 METRIC TONS.

	1850		1898		1899	1900
	1,000 tons	Per Cent.	1,000 tons	Per Cent.		
United States....	5,776	9·	198,071	32·3	230,000	243,414
United Kingdom.	45,328	67	205,287	34·	223,616	226,772
Germany...	5,184	8·	96,310	16·	101,640	149,551
France..........	4,437	7.	32,356	5·	32 331	33,404
Belgium.........	5,820	9·	22,088	4·	22,072	23.462
Russia	52	......	13,000	2·	13,100	15.000
Austria-Hungary.	584	......	12,786	2·	12,694	39,027
Australasia	....	......	6,414	1·	6,470	7,477
Japan	....	.....	6,000	1·	6,721	7,429
India	....	......	4,679	0·8	5.016	6,216
Canada	164	......	3,785	0 6	4,467	5.088
Africa...........	....	....	2,550	0·4	239	495
Spain	....	......	2,467	0·4	2,600	2.582
Other Countries..	63	......	3,077	0·5	2,500	2,500
Total...	67,405	100·	608,870	100·	663,466	764 427

*The statistics for 1850, 1898 and 1899 include only the production of "steinkohle," anthracite and true bituminous coal, of Germany and Austria-Hungary. The production of "brown" coal for the years mentioned was in Gemany respectively as follows in thousand tons: 1522, 31649 and 34000. In Austria-Hungary the production of this coal in the three periods was 360, 25000 and 26345 thousand tons respectively. Coal mining in Japan according to modern methods dates from 1873. In the Transvaal the mining of this substance dates from about 1890.

It will be seen from the table that the relative output of the various countries has changed greatly during the century. In the last two years the output of Great Britain has, in spite of the fact that it had always been on the increase, been surpassed by that of the United States. After the former country comes Germany; then at a considerable distance France and Belgium, and finally Russia and Austria-Hungary. The coal industry flourishes in many other countries than those mentioned. Japan, India, Siberia, Canada, Transvaal, and Australia produce important quantities.

The most important coal fields of Japan are on the southernmost part of the large island of Kiuschiu, the most important workings being at Miike. Other mines are on the northern part of the island in the vicinity of Tschikussen, whose shipping harbor is Wakamatsu, in the neighborhood of which are the recently erected steel works. There is also an important coal industry on the north island Jesso.

In Siberia coal mining has been carried on for some forty years, for supplying the Russian fleet in the Pacific Ocean. The new railway has given an impetus to coal mining in other parts of Siberia.

The districts in China in which there is an important industry lie near Kaiping, northeast of Tientsin with which they are connected by a railway. Other large coal fields are known in this empire.

The total of the year's production of coal on the earth in 1900 amounted to more than 700,000,000 tons. Since it is extremely difficult to get a clear conception of this mighty mass we may state that this quantity of coal would form a cube which would have a length on its edges of something like 1 km. (=0.62 English mile).

If this mass of coal were placed on railway carriages, each of 10 tons capacity, a single train formed of them would have a length of 630,000 km. Since the earth's equator has a length of 40,000 km., a railway track long enough to accommodate these cars, all at one time, loaded with the yearly output, would girdle the earth nearly 16 times, one car occupying a space of 9 m.

The most important use of coal is in the production of steam for power; then there is the demand for fuel for household purposes. While, as already stated, coke was in use in Great Britain for smelting in the 18th century, it was so used on the continent and in North

America first in the 19th. The production of gas for lighting originated in our own century. Both the last-named industries, the production of coke and gas, are of great importance on account of their by-products, tar and ammonia, which are obtained in large quantities.

Coal tar is at the basis of a highly developed branch of the chemical industry. From it a great variety of antiseptic and medicinal materials are obtained—creosote, used in the preservation of wood, napthalene, phenol, salicylic acid, antipyrin, phenacetine and saccharine, which in many cases takes the place of sugar. Benzol must also be mentioned, being used in the chemical industry as a solvent for fats, etc. It also serves for the improvement of illuminating gas. From the tar industry are derived the analine dye materials which were made known through the work of the chemists, A. W. Hoffman and W. H. Perkin, 1856.. Two other important dye materials, alizarin and indigo, which have long been known, but which were formerly obtained from plants, have in recent years been artificially produced from distillates of tar.

The residue, or hard pitch, from tar distillation, which remains after a temperature of 400°C is reached, now plays an important role in a wider branch of the coal industry, viz, in the briquetting of fine or dust-like coal. It forms the binding material for the briquettes. The briquetting of coal and peat is becoming an important industry. In Germany in 1900 some 1,700,000 tons of the ordinary varieties of coal and 5,000,000 tons of brown coal briquettes were produced.

Paraffin and mineral oil have since 1855, in important quantities, been derived from brown coal. At the present time more than one million tons of this coal are consumed annually for this purpose.

OTHER METALS.

In the production of silver, the United States takes the lead; then follow Mexico and Bolivia, then Australia, and in the fifth place Germany. A considerable part of the silver produced in the last named country comes, however, from foreign ores. The celebrated silver mining districts in the United States are the Comstock lode in Nevada, discovered in 1858, which has already been referred to, since in addition to silver it has produced much gold, and the deposits of Leadville, in Colorado, where operations were begun in 1876. In Mexico and Bolivia the mines are for the greater part short lived, but they have produced an important amount of silver. The mining here usually ceases at shallow depths, since these countries have often been the scene of revolutions which deter capitalists from investing in machinery. Thereto has been added the lack of good coal and transportation facilities. In Australia the celebrated Broken Hill mines are large producers of silver.

The United States at the present time turns out three-fifths of the world's production of copper. This comes chiefly from two districts, the south shore of Lake Superior, in operation since 1855, although worked to some extent in pre-historic times, and Butte in Montana. The latter district has been known since 1877 as a producer of silver and gold. In 1883 its copper deposits attracted attention.

Next to the United States, Spain produces the greatest amount of copper, chiefly from the famed Rio Tinto mines, which were known to the Romans. Then follow Chili and Japan. In the former country copper mining has been active since 1855, at least "Chili bars" have since that year been quoted on the London Exchange. In Japan active metal mining dates from the end of the 60's.

In Germany the old Mansfield mines produce by far the most copper. In June, 1899, His Majesty the Emperor took part in the celebration of the 700th year of the working of these mines.

In Australia, whence comes an important quantity of copper to the world's markets, mining began in this metal with the discovery of the celebrated deposits of Burra-Burra in South Australia in 1845.

The demand for copper for use in electrical apparatus has given an extraordinary impetus to production, which in 1890 was 274,000 kg and in 1899, 477,000. The price has also changed. At the beginning of the 90's it fluctuated between 90 Pf. and 1 M. per kg., and has since risen to 1.50 M. The result is that everywhere copper mining has taken on new life. How great the use of this metal is in Germany can be seen from the statement that in 1899 this country consumed 98,000 kg., a larger amount than that used by any other European country.

Other metals will now be referred to briefly. The great lead deposits of Leadville and Broken Hill have already been mentioned in connection with silver. The new tin workings on the island of Billiton are important, discovered in 1852. The metal has been known in the neighboring island of Banka since the 18th century. The deposits of Mt. Bischof in Tasmania, 1873, should also be mentioned. During the last hundred years a group of quicksilver localities have been found in New Alameda, New Idria and Sulphur Bank in California, and Nikitowka in the South of Russia, since 1888. The celebrated quicksilver deposits in Huancavelica in Peru, which produced a large quantity of material for the amalgamation of South American silver ore was, however, abandoned in 1830. This furnishes us with an example of the effects which the working of new deposits often has on the existence of older industries.

Among the most important mining industries of our century cannot be left out that of the celebrated Kimberly in South Africa. In 1867 diamonds were here found in rock in place, while these gem stones in all other districts occur in loose deposits or in detrital matter. The DeBeers Company, which now operates these deposits, absolutely controls the diamond market.

NEWER METALS.

To the group of seven metals of ancient times, the noble metals —gold and silver—mercury and the useful metals copper, iron and steel, tin and lead, with the alloys bronze and brass, have been added in our century an important number of new ones. The surprising fact is that during the first eighteen hundred years of the Christian era, only a single metal, antimony, which, alloyed with lead and other metals, came into use in the 15th century, was discovered.

The new useful metals of the 19th century are: zinc, platinum, nickel and aluminum, together with manganese, chromium and tungsten, bismuth and magnesium. There are thus added to the seven earlier known metals nine new ones, which are not mere chemical curiosities or parts of compounds, but metals which take a prominent place in industry and are used on a large scale.

In adding zinc to the group of the new useful metals of the 19th century, an explanation is necessary. The oxidized zinc ores—zinc carbonate and zinc silicate, commonly called calamine—were from very early times into the 18th century smelted with copper to form brass. In our century, however, zinc has been used by itself as a distinct metal, as well as in alloys. Dr. Helm has, it is true, described as a curiosity a zinc object dating from prehistoric times, but not generally till about 1800 was zinc in use as a simple metal. The great quantity of zinc which, before the beginning of our century, was produced in England, and about 1800 in Silesia, Belgium and elsewhere, found application exclusively in alloys. The discovery, about 1820 that zinc could be vaporized if heated to 100° C, caused an important advance in its metallurgy. After this zinc began to be used in castings and in the plating of iron. In this way zinc has become an industrial metal of the 19th century.

The important zinc-producing countries at the present time are Rhineland, with the neighboring parts of Belgium and Holland, Upper Silesia and the United States. In the last named country the first zinc smelters were built, in 1850, shortly after the zinc deposits of Franklin in New Jersey, and Bethlehem in Pennsylvania, had begun to be worked. Especially important are also the Sardinian deposits, from which most of the ore is taken to Belgium to be smelted.

It is noteworthy that up to about 1850 all the zinc produced came from calamine. After this zinc blende came into use. Through this has resulted the re-opening of some very old mines in Rhineland which had formerly been worked for lead.

Platinum and nickel were known in the 18th century. The former metal was discovered in association with gold in Columbian sands in 1750. Nickel was recognized as a simple metal in 1779; but the industrial application of both of these metals belongs to the 19th century.

Attention was next directed to platinum through the discovery of it in the Ural mountains in 1819. In 1824 a considerable amount of it was produced. The desire of the Russian government to find some use for the metal which had accumulated in the treasury, resulted in 1828–30 in the coinage of it, there being something like 14,000 kg. coined. But the coin enjoyed no popularity, and soon came back into the treasury. First, about 1860, a demand arose for platinum through its growing use in connection with chemical manufacture, especially for laboratory utensils, and for vessels used in the production of sulphuric acid. Further applications have been found for the metal since 1880 in electric apparatus. The largest amount of crude platinum has always come from Russia, a little also being supplied by Borneo. The production of refined platinum is carried on in Germany and England; the yearly production amounts to between 4,000 and 5,000 kg. The price has been increasing for many years. In 1875, 1 kg. was worth about 1,000 M, while at the present time it is 2,300 M, or close to the value of gold. Platinum has, at one or two periods during late years, been higher in price than gold.

The closely related metals, palladium, iridium, rhodium, ruthenium and osmium, which occur associated with platinum, are obtained as by-products in refining this metal. Iridium is, on account of its extreme hardness, made use of in forming the points of pens. Osmium which has the highest melting point of all known metals, and has up till recently been produced only in the form of powder or a spongy mass, is now used as a fine wire in electric lamps.

The production of nickel on a commercial scale dates from 1823. It was then, and for some time afterwards, used solely in alloys, namely, in nickel (German) silver. The customary compositition of this alloy is 50–66 per cent, copper, 18·5–13 per cent. nickel, and 31–19 per cent. zinc or tin. Utensils, known as white copper and having a similar composition, come from China. Another important alloy of nickel, of the composition 25 per cent. nickel and 75 per cent. copper, is used in coinage. The Swiss used this first in coinage in 1850, later the United States, then Belgium and Germany in 1871. France has recently introduced her first nickel coin; it has a value of about 5 American cents. Through the endeavor to find new applications for the metal, it was learned how to roll and press it. This made it possible to use the metal in the manufacture of many useful articles, such as table and kitchen utensils, and to turn the metal into coins. The Austrian 10 and 20 half-penny pieces are composed of the pure metal.

Galvanic plating with nickel has risen to an important industry. Finally, since 1890, an alloy of approximately 5 per cent. nickel and steel—nickel steel—has been largely used for armour plate. This use gives rise to the largest demand for the metal.

Of similar interest to the wide application of the metal, is the change which has taken place as regards its productive territories. Outside of Schneeberg in Saxony, Scandinavia was one of the earliest producers of the metal. The chief and about the only producers of the ores of this metal are, at the present time, New Caledonia and Sudbury, the ore of the former country being a magnesian silicate, and of the latter pyrrhotite. It may be added that small amounts of the closely related metal, cobalt, are practically always associated with nickel. The workings in New Caledonia were begun in 1874, and there was an important output in 1880. Development at Sudbury began in the later 80's. Inversely as the production of the metal has increased, the prices have fallen. The annual production is now about 7,000 tons, and the price per kilogram has fluctuated, during the 25 years of extraordinary expansion in production, from 10 to at times 30 M, according to changing demands, and has now sunken to about 2½ M.

The fourth of our modern industrial metals is aluminum. It was first produced as a metal in 1855, yet it was up to about 1890 so high priced—the price being something like 50 M per kg.—as to prohibit its becoming widely used. Cryolite served as the first raw material for this metal. This mineral is found in large quantities only at Ivigtut, on the southwest coast of Greenland, and has been mined in large quantities by the Danish government since 1857. The natural aluminum hydrate, bauxite, which occurs in large quantities in France and the United States, is now used as a source of the metal, and the use of the electric furnace in 1891 first made possible the production of the metal on a large scale. At the present time the price is only about 2 M per kg. In 1899 about 6,000 tons were produced.

The hope that aluminum, the specific gravity of which is only 2.6, would serve as a light metal, has not yet been fulfilled, since its use brings up many difficulties. Considerable amounts of the metal find use in the chemical industry, it being used as a strong reducing agent in the production of metals, *e. g.*, chromium, which are reducible with difficulty. In foundry work a little aluminum is sometimes added to molten iron in order to prevent the formation of blow holes in castings. It is also used quite widely for cooking and other utensils. Recently aluminum wire has begun to be used in the place of copper wire for the transmission of electricity.

Another important light weight metal is magnesium, its specific gravity being only 1.7, which is considerably less than that of aluminum. For more than 200 years magnesium sulphate, or bitter salt, has been known as a constituent of mineral water and medicinal springs. The metal was first produced by Davy in 1808. At the present time it is obtained in large quantities through the electrolysis of molten carnallite, a double compound of magnesium and potassium chloride, which comes in large quantities from the potash salts of North Germany. The metal finds use as powder, wire, or strips, solely in the production of strong light in fireworks and photography. In spite of this restricted use, the yearly production is 5,000 kg. The tests which have recently been made of magnalium, an alloy composed of about 80 per cent. aluminum and 20 per cent. magnesium, are of interest. This alloy is a light metal, and is said to be superior in many respects to pure aluminum. More important than the production of the metal is that of the artificial magnesium sulphate, which is used in great quantity in the cotton industry.

The metal bismuth was first produced in quantity about 1830, although it had been earlier known. It serves, in combination with lead and tin, for the production of an alloy which melts at a low temperature, and is used in safety apparatus for steam boilers and for other purposes. The salts of the metal are used in medicine.

Bismuth ores are obtained in large quantities at Schneeberg, Germany, and a further supply of rich ores comes from Tasmania and Bolivia.

Finally, we may now consider the applications which the ores of manganese, chromium and tungsten have found in the second half of the 19th century, both in the chemical and iron industries.

In early times manganese ore, pyrolusite, was used as a source of oxygen. The metal itself is now largely used in alloy with iron, manganese steel possessing properties which make it extremely valuable for certain purposes. There are yearly about 1,000,000 tons of manganese ore produced, Russia supplying the greater part, followed by the United States and Spain, then come India and Germany.

About 45,000 tons of chrome ore are marketed yearly, the chief producers being New Caledonia, Russia, and Asia Minor. Like manganese, chromium finds use in the chemical industry in the preparation of various salts, and also in the production of chrome steel.

Only a small quantity of tungsten ore, some hundred tons, is consumed annually. It comes from the United States, Australia, and Zinnwald, Germany. Tungsten steel is a highly prized alloy for certain uses.

Molybdenum is another metal which is now beginning to be used in alloy with steel. For the manufacture of tools, such as chisels and planes, molybdenum steel is said to be especially valuable. There are only two known minerals which occur in quantity and contain molybdenum in large amounts. They are wulfenite and molybdenite. The former is found in quantity at Bleiberg, in Carinthia, and the latter is mined in Norway.

MINERALS IN CHEMICAL INDUSTRY.

We shall now pass from the metal industry to that of chemical manufacture. While the former was of importance at the commencement of the 19th century, the latter had scarcely made a beginning and was confined chiefly to to the production of sulphuric acid, potash, sal-ammoniac, and saltpetre. Compared with the demands of to-day, the output was very small. We shall refer to those raw materials only which were first made use of in our century.

Since about 1850 an important and numerous series of experiments have thrown light on the value of mineral manures, after the agricultural chemists had set right the older views on fertilizers and shown that plants for their growth require certain elements, namely nitrogen, phosphorus and potassium. The raw materials for these are Chili saltpetre, guano, the natural phosphates, and potash salts. The slags produced in the working of phosphorus-holding iron ores by certain processes, which have already been referred to, are another source of this valuable element for use in agriculture.

Saltpetre, the potash variety, is formed widely where the remains of plants and animals, or the excreta of the latter, decay under favorable conditions. In the Province of Bengal, for example, this material is produced in large quantities by mixing earth with animal excreta, turning the mixture over from time to time, and after, it may be some years, washing out the salt with water. The saltpetre thus produced is largely used as a manure in the East Indies.

About 1821 large deposits of soda nitre, known as Chili saltpetre, were found on the rainless west coast of South America. This district is the chief source of the raw material for the saltpetre industry. The nitre is found on the Rio Loa, the former great river between Bolivia and Peru, at Caracoles and Taltal. The raw material is there called caliche. The pure saltpetre is obtained by dissolving out the salt with water and allowing it to crystallize. An industry has been established since about 1830. In 1899, 1,360,000 tons of saltpetre were produced, about one-third of which went to Germany, the price being about 160 M. per ton at Hamburg. A large part of the Chili nitre is transformed to potash nitre by the use of the potash salts of North Germany, the potash variety then being known as conversion saltpetre. It is used as a fertilizer, and forms one of the chief constituents of gun powder. Nitric acid, which plays a great part in the chemical industry, is also produced from saltpetre. The greatest part of the iodine of commerce is obtained from the residues of the saltpetre crystallization.

The high value of guano depends on the fact that it contains a high percentage of ammonia salts and nitrogenous organic substances, as well as calcium phosphate. As the last mentioned compound is not soluble in water, the guano must, in case it is to be used as a manure, be treated like the naturally occurring phosphate, apatite, by the process invented by Liebig in 1840. In this process the phosphates, after treatment with sulphuric acid, give soluble compounds. Since the nitrogen-holding constituents of guano are soluble in water, it is evident that this material is only to be found in arid climates, such as that of Peru and Bolivia. This guano is known to be composed of the excreta and the remains of the food of sea birds. While the guano of South America has been used as a manure for over a century, it was shipped to Europe first in 1840, and the production has greatly increased since 1850. The most valuable guano deposits of South America are now exhausted.

The mineral, calcium phosphate, also serves as a raw material for the superphosphate industry. It is found in two forms, crystallized as apatite, and rock-forming phosphate. The first occurs, *e. g.*, in South Norway and in Central Canada, and in the Spanish province of Estremadura, in large quantities; the rock phosphate, phosphorite, is found on the peninsula of Florida. These natural phosphates are insoluble in water, and must therefore be changed into the soluble form by the process already mentioned.

The rich store of potash salts, and associated magnesium salts, in north Germany, which at present monopolizes the world's trade in these materials, was first worked in 1861. At that time the industry was started at Stassfurt and Leopoldshall and later at numerous other points. Both production and demand increased remarkably quickly. 2,500,000 tons represented the total output up to 1899. A large number of works are engaged in treating this raw material, and the export trade is large, the trade being entirely in the control of the Kali Syndicate.

It may be stated that the valuable material bromine is produced from the residues of the potash salts. It, and the closely related element iodine, find wide application.

Boracic acid is also derived from a mineral found with the potash salts. Another compound of this acid, the natnral borax, occurs in large quantities in the so-called borax lakes, *e.g.*, in California and Thibet.

Another industry, the winning of rock oil—international naptha—has reached great importance during the last 40 years. Its beginning dates from 1859. In that year the first well was bored at Titusville in Pennsylvania. Raw oil and its products now represent not only a mighty home industry in North America, but an enormous export trade has also been built up. A second important rock oil locality is that of Baku on the Caspian Sea. This has been developed since 1870. The importance of the rock oil industry is seen from the fact that 16,000,000 tons of the material are produced annually. About half of this comes from the United States and half from Baku, while Canada, Austria, India, and Roumania produce comparatively small quantities. Oil has been discovered in many other places, *e.g.*, in the East Indian Islands. German native production, which is very little, comes from the vicinity of Hanover and from some parts of Alsace. Thus nearly the whole German consumption depends on imports, which amounted, in 1899, to nearly 1,000,000 tons, valued at 65,000,000 M. The winning of oil and its transportation are somewhat unique industries.

We shall now refer briefly to some mineral products which are of comparatively small importance commercially, but which are of considerable scientific interest.

The compounds of thorium, cerium, and yttrium have had a commercial interest since Auer von Welsbach utilized them in the mantle of his gas lamp. His first patent was taken out in 1885. Previous to this, these compounds were known only as the constituents of certain rare Scandinavian minerals. The increase in price and demand for these materials gave rise to a diligent search for them. They were found in North America, and later in Brazil in the pea yellow mineral, monazite, which is the source of these earths to-day. The last named country is by far the most important producer.

While 1 kg. of thorium nitrate in 1894-5 cost 2,000 M., the price now is about 30 M. Auer's mantle, the manufacture of which has produced a use for these rare materials, is now composed of 99 per cent. thorium oxide and 1 per cent. cerium oxide; the mantle holds about one half gram of this mixture, and gives a nearly pure white light. The original greenish color of the light was due to the impurity of the thorium salts. From forty to fifty thousand of these mantles are now in use daily in Germany.

Lithia, mica, lepidolite, which contains about 3 per cent. of the rare element, lithium, serves as the chief source of the lithia salts, which are used in medicine in connection with many complaints caused by urinary secretions. The yearly consumption of these salts is from 2,000 to 3,000 kg. Lithia mica occurs in large quantities at Vinnwald, in Germany.

Barium compounds are also used in important quantities at the present time. They include barium sulphate, known as barite or heavy spar, and the carbonate, witherite. The consumption is between 20,000 and 30,000 tons annually. The greatest quantity of heavy spar, after the material is ground and cleaned, serves as a valuable paint, known as permanent white, being for some purposes preferred to white lead. Barium salts, especially the chloride, find many applications in the chemical industry. Barite occurs in many places in Germany and elsewhere. Witherite is mined in large quantities, chiefly in the north of England.

Near these barium compounds stand the closely related compounds of strontium. The chief of these are strontianite, the carbonate, and celestite, the sulphate. Strontium salts give a red color to a flame, and are hence used in fireworks. Since 1871 strontium hydroxide has had an important use in the refining of sugar, as have also the hydroxides of barium and calcium.

Celestite is mined chiefly in Sicily, where it occurs in association with native sulphur.

Strontianite is mined in Westphalia. Germany imported in 1899 over 8,000 tons of strontium compounds.

Compounds of uranium, another somewhat rare metal, came first into commerce in 1830. The largest quantity of its ore, pitch blende, is produced in the silver mines of Joachimsthal, in Bohemia. Uranium is used in the glass industry to produce a yellowish green fluorescent glass. It is also used to produce black and yellow colors for painting porcelain.

We may now, in concluding this survey of the economic minerals of the 19th century, refer to the wide applications which have been made of mica and asbestos during the last 20 years. Both of these minerals have been known since ancient times, and various uses have been found for them in different ages. Each of the two is non-combustible, and in a high measure proof against the action of acids. They both conduct heat and electricity badly. The structural characteristics of both are striking. Mica is easily recognized by its thin, flexible and transparent cleavage plates. This makes the mineral valuable for certain purposes. For other purposes powdered mica is used. Asbestos, when of good quality, can be separated into fine fibres, which can be spun like cotton. The less valuable varieties serve for the production of pasteboard. In the powdered form it makes up an integral part of fire-proof paint. Both asbestos and mica find a wide use as refractory materials, and are used extensively in various forms as insulators. Quebec is by far the greatest producer of asbestos, which is the serpentinous variety. Mica, suitable for commercial purposes, is found as a constituent of coarsely crystallized granites and syenites, the so-called pegmatites in India, the United States and elsewhere. The mica found under these conditions is the potash variety, muscovite. In Ontario and Quebec, which, with the countries just mentioned comprise the chief mica producers, the variety mined is phlogopite, magnesian mica. Sheets of phlogopite from one mine in Ontario, at times, have a diameter of 6 or 7 feet. Phlogopite occurs in deposits which evidently are of secondary origin, the constituents frequently including large crystals of apatite, pyroxene and calcite.

Other minerals, *e.g.*, graphite and magnesite, are also used extensively as refractory materials. The wide use of certain minerals and artificial compounds for abrasive purposes may also be mentioned.

If we look at the testimony of mining in our century, we find that the technology of more than 20 mineral groups has been worked out. Uses have been found for some long known minerals, and the applications of others have been widely extended. Other minerals have been discovered during the century, and commercial uses have been found for them. Mining has thus, through the turning into wealth of such a vast variety of materials, added much to the prosperity of the peoples of the earth.

To complete our account of the progress during the century it may be well to glance at the wide geographical distribution of industries which mining now exhibits. Mining is carried on the farthest north on the European continent; a copper mine at Alten, south of Hammerfest, is in about 70° north latitude; there is important copper mining at Sulitjelma in Norway, about 67° north latitude; on the Swedish side there are iron mines as far north.

On the new Siberian islands in the Arctic Ocean, which reach to 75° north latitude, a peculiar kind of mining is carried on. The buried remains, some of which are in an almost perfect state of preservation, of mammoth are excavated from the everlasting ice. This mining is not so insignificant as one might think, since about 20,000 of these remains have been found in Siberia. As the remains are those of extinct animals, and are used not as specimens, but for what may be called true commercial purposes, the industry has a right to be called mining.

The cryolite mine, at 61° north latitude, in Greenland, has already been mentioned; then on the west side of the American continent are the Yukon gold fields, in 64° north latitude.

In the southern hemisphere mining can naturally not be carried on so far distant from the equator. The division of sea and land is there different from what it is in the far north. The most southern point where mining is carried on is Punta Arenas, in the straits of Magellan Here, at times, a supply of coal is secured. The nearest workings to this lie much farther north; they are the coal mines of Coronel. Near by are the copper works, in 37° south latitude. South Africa reaches only to about 34°, her most southern mines of importance being the diamond workings of Kimberly and the gold deposits of Johannesburg. On the island of Tasmania, which lies south of Australia, mining is carried on actively at various points. In the most southern part of New Zealand, Otago, profitable gold mines are in operation.

Molybdenite—Its Occurrence, Concentration and Uses.

BY J. WALTER WELLS, M E., Kingston, Ont.

As the uses of mineral molybdenite are being extended, the writer undertook some experimental work at the ore dressing laboratory of the Kingston School of Mines, to determine the different methods of concentrating its ores, and it was thought that the results might be of interest to the members of the Canadian Mining Institute.

Molybdenite when pure contains 60 p.c. molybdenum and 40 p.c. sulphur, and may be represented by the formula MoS_2. A sample selected by the writer from an Ontario specimen carried—

Mo	58.56 p.c.	S	38.34 p.c
SiO_2	0.32 "	Fe	0.79 "

It is commonly found foliated, massive in scales or finally granular. Sometimes it is found in nature as hexagonal crystals more or less tabular or as short tapering prisms horizontally striated.

The cleavage is basal, the laminae being very flexible but not elastic. It may be easily cut with a knife the hardness being 1 to 1.5 Its specific gravity is 4.7. The lustre is metallic and the color a lead to silvery gray. It is opaque, and very greasy leaving a gray-blue trace on white paper. It closely resembles graphite in softness and physical structure but gives a bluer trace on paper and shows sulphur reaction with soda on charcoal. The difference in graphite and molybdenite was pointed out by Scheele in 1778.

Heated on charcoal molybdenite gives a strong odor of sulphur with the oxidizing flame coating the charcoal with molybdenum dioxid which is yellow while hot and white on cooling. If the white coating be touched with a reducing flame it gives a beautiful blue color along with a copper-red, Molybdenite in infusible in the blue-pipe flame imparting a greenish-yellow color to the flame. It oxidizes in the open tube giving sulphurous fumes and a yellow sublimate of molybdenum dioxid. It is decomposed by nitric acid and more readily by a mixture of nitric acid and potassium chlorate, leaving a white residue of molybdenum dioxid, soluble in water, the solution when reduced with zinc and sulphuric acid turning a blue, green and finally on olive brown.

OCCURRENCE OF MOLYBDENITE IN CANADA.

Molybdenite seems to be a common mineral in Canada judging from reports. It is commonly found associated with other sulphides such as pyrite, pyrrhotite, and chalcypyrite. At the Giant mine, Rossland camp, British Columbia, the gold values seem to depend on the amount of molybdenite present. According to Hon. C. H. McIntosh as reported in Rossland Miner, Feb. 19, 1903, a sample of ore from the Giant mine rich in molybdenite sent to Vivian & Co., Swansea, England for analysis carried the following:—

Molybdenum	24.20	per cent.
Nickel	trace	
Cobalt	1.00	"
Bismuth	.19	"
Arsenic	1.80	"
Sulphur	23.00	"
Copper	trace	"
Lead	trace	"
Zinc	nil.	"
Antimony	nil.	"
Silica	35.00	"
Iron-metallic	12.00	"
Lime, magnesia, etc	2.30	"
	99.49	

Gold—4.14 ounces per ton of ore.

Silver—1.2 ounces per ton of ore.

Molybdenite is often found in quartz veins where its presence does not indicate the presence of gold according to assays made by the writer. It is a common accessory mineral in granites, gneiss, pegmatites, etc. The report of the Canadian Geological Survey note the following localities where molybdenite may be found:—

1. At the mouth of Burnt Hill brook, a branch of the south west Miramichi, New Brunswick, where the molybdenite was found in quartz veins cutting schistose rocks but not in commercial quantity.

2. In quartz veins at various points along the Atlantic coast in Cape Breton.

3. In quartz veins cutting granite near Gaspereaux Station, New Brunswick.

4. In quartz veins at Pennfield, Charlotte County, New Brunswick, 2 miles north of the post road on Trout brook where the quantity is said to be considerable.

5. In syenite near Gaspereaux river road in New Brunswick.

6. At lot 12, 12th concession of Templeton, Quebec, intermixed with pyrite.

7. At lots 1 and 2, 3rd range of Aldfield Township, Pontiac County, Quebec.

8. At lot 69, 4th concession of Egan Township, Ottawa County, Quebec, where there is said to be a large deposit associated with pyroxene, mica, pyrite, etc., carrying 7.5 p.c. molybdenum dioxide.

9. At lot 7, 9th range of Ross Township, Renfrew County Ontario, where a vein carries molybdenite associated with apatite, scapolite, titanite, pyrite, etc.

10. In Matawanchan Township, Renfrew County, Ontario, the locality being not well defined.

11. At lot 22. 2nd range of Ross Township, Renfrew County, Ontario, where a quartz vein in gneiss is said to carry considerable molybdenite.

12. At Quarry Island, Rainy River District, Ontario, where the gneiss as country rock shows specks of molybdenite.

13. Around Lake Nipissing, Ontario, as an occasional constituent in quartz veins.

14. A specimen is reported from upper Cowitchen river, British Columbia.

15. In association with copper ore at a locality between Jarvis, Inlett and Howe Sound, British Columbia.

16. In the Atlin district it may be found as an accessory constituents of gneiss and in quartz veins especially at the head of Volcanic creek.

17. Float carrying considerable has been found in the vicinity of Great Slave lake.

According to the Inspector of Mines for Nova Scotia specimens of molybdenite may be found in that province at Gabarus, Hammonds, Plain Bedford, Lower Musquodoboit, New Germany and New Ross.

The Inspector of Mines for Quebec reports molybdenite in workable quantity in quartz veins at Quetcho-Manicougan: at lot 27, 15th concession of Leeds Township, Megantic county: at the northern part of 13th range in Calumet Island.

According to the reports of the Bureau of Mines for Ontario, molybdenite may be found more or less abundant at the following localities:—

1. Lot 3, 8th concession of Miller Township, Frontenac County.
2. At Black river, Lake Superior region where a considerable quantity is reported.
3. At lot 14, 5th concession of North Crosby, Leeds Township.
4. At lots 26 and 27 in 6th concession, Monteagle Township, Hastings County.
5. Near Farquhar lake in lot 3, 1st concession of Harcourt Township, Haliburton County, where a considerable deposit has been opened up by the Haliburton Land and Immigration Co of Toronto. Five veins traversing pyroxenite as country rock have been exposed carrying molybdenite with pyrrhotite, tremolite, pyrite, mica and sphene. The total exposure is 300 yards long and 80 yards wide on which test pits have been sunk. Average samples from this property carry about 2 p.c. molybdenum.
6. Several localities are reported where the molybdenite appears to be only an accessory mineral in country rock or pegmatites.

The writer also knows of the following important deposits not mentioned as they are but recently discovered:—

1. At the centre part of lot 5, 11th concession of Laxton Township, Victoria County, Ontario, near Mud Turtle lake. Development work done by the owner, Mr. J. Webber, Toronto, shows a vein about 15 feet wide cutting crystalline limestone. The vein has been stripped for 40 feet by an open cut and shows molybdenite in large and small flake associated with pyroxene, calcite, quartz, black mica, pyrites, a few specks of pyrrhotite and hornblende. A 50 lb. sample submitted to concentration tests as further described carried 3.28 p.c. molybdenum.
2. At the south part of lot 5 in the same locality as (1) where a

narrow vein carrying molybdenite may be traced 5. Three pits sunk about 30 feet apart show molybdenite in considerable quantity and fairly rich. The associated minerals are quartz, calcite, pyrite, molybdenum ochre due to weathering action and pyroxene.

3. On the farm of T. Dwyer, Sheffield Township, Addington County, there is a mineralized zone carrying pyrrhotite, pyrite, hornblende, calcite, quartz, pyroxene, black mica, etc., in which foliated masses of molybdenite occur some of the masses being 6"x6" while it may be as fine flakes.

Development work done by the owner, Mr. A. M. Chisholm of Kingston, has produced a pile of 1,000 tons of ore and the deposit does not seem to be exhausted. Average samples selected by the writer carried 2.8 p.c. Mo and 260 lbs of selected ore subjected to concentration carried 3.90 p.c. Mo.

4. A deposit is known to occur near Granite crossing, British Columbia, where the C. P. R. crosses Kootenay river. Five claims have been taken up by Mr. T. L. Stamford of Nelson, on a vein mostly quartz traversing altered granite as country rock. The molybdenite occurs as fine flakes in the quartz and there is more or less of reddish felspar present. A 20 lb. sample from this locality submitted to concentration tests by the writer carried 1.5 p.c Mo.

Molybdenite is reported to have been found in considerable quantity at Rencontre, Fortune Bay, Newfoundland.

A deposit has been found near the White Pass Tunnel above Skaguay in the Yukon Territory carrying considerable molybdenite with high gold values.

CONCENTRATION TESTS ON CANADIAN MOLYBDENITE ORES.

Molybdenite has come into industrial use only within the last few years on a large scale so that there is practically no literature regarding the methods of concentration or dressing its ores. As it is a common mineral in Canada and its industrial uses appear to be increasing, some commercial method of extracting the mineral from its ores is needed. Accordingly the writer submitted several samples to concentrating tests at the ore-dressing laboratory of the Kingston School of Mining with the object of finding a simple and efficient method of concentrating molybdenite from the low grade ores.

Sample A comprised 260 lbs of ore from a deposit in Sheffield Township, Addington County, Ontario, already noted. Plate 1 is a characteristic specimen showing the flakes of molybdenite segregated in the matrix. The sample carried about 50 p. c. pyrrhotite, 10 p. c. pyrite intermixed with calcite, black mica, quartz, pyroxene, etc. The sample carried 3.90 p.c. Mo. equivalent to 6.5 p.c. molybdenite. All of the molybdenite was in the form of small scales or segregated masses as the ore was selected to see what could be done with the fine flakes. Hand picking of the large flakes is obviously the easiest method of securing a marketable product but the removal of the fine flakes is more difficult.

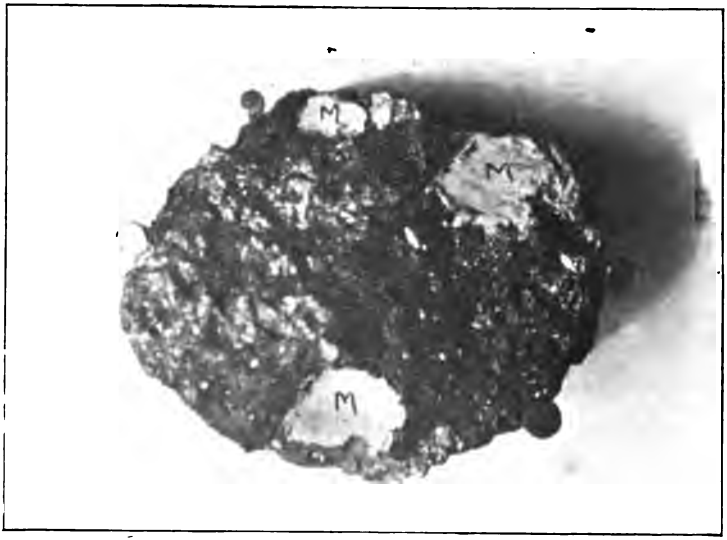

Photo showing Molybdenite in flakes (M) found in Pyrrhotite.

The sample was crushed in jaw crusher, passed through rolls and screens with slots of 0.20″ diameter. Molybdenite as large flexible flakes not reduced in size by rolling was picked from the screen.

Such ore weighing 3 lb. carrying 54.3 p.c. Mo equivalent to 90.05 p.c. molybdenite.

The ore was then crushed in the rolls to finest possible size and passed through the screen of 0.20″ diameter delivering an oversize weighing 3.5 lb. consisting of mica and molybdenite with a few particles of pyroxene. Neither mica nor molybdenite were much affected by passing through the fine rolls owing to the flexible and laminated structure.

A few particles of the molybdenite had particles of pyrite and pyrrhotite imbedded in the soft flakes. The ore passing 0.20″ screen was passed to screen delivering product of 0.10″ diameter and finer while the oversize consisting of mica, molybdenite with a few particles of rock weighing 4 lb. in all was removed. The ore reduced to 0.10″ size was passed through a Wetherill magnetic separator removing 134 lbs. of almost pure pyrrhotite as a magnetic product showing by analysis:—

Fe	60.30 per cent.
Sulphur	38.97 "
Nickel	0.34 "
Molybdenum	traces.
Cobalt	traces.
Platinum	traces.
Copper	traces.
Gold	0.04 ounces per ton of ore.
Silver	traces.

The tails from the magnetic separator carry:—

Sulphur	5.49 per cent.
Nickel	traces.
Molybdenum	0.46 "
Copper	traces.
Gold	traces.
Silver	traces.
Platinum	traces.

The tails from the magnetic separator passed through a straight line hydraulic separator delivered heads carrying—

Sulphur........ 5.08 p.c. Molybdenum..... 0.34 p.c.

to a Wilfley table while the tails consist largely of mica, crushed particles of rock with a few flakes of molybdenite.

The Wilfley table gives a head product weighing 11 lb. carrying—

Sulphur....... 41.93 p.c. Molybdenum...... 1.32 p c.

being mostly pyrite fit for making sulphuric acid. The middles from the Wilfley samples as being returned to the table for retreatment carry—

Sulphur....	3.64 p.c.	Molybdenum......	0.12 p.c.

While the tails carry—

Sulphur........	2.74 p.c.	Molybdenum......	0.10 p c.

neither being of any commercial value but showing that the Wilfley table is adapted to the ore for removing the pyrite if it is necessary or profitable to do so. The object of removing the pyrrhotite as one product was to get an ore of nickel if possible but there is not sufficient nickel present to make it worth while so that probably the pyrite and the pyrrhotite might better be separated on the Wilfley as an ore of Sulphur.

Attempts were made to remove the molybdenite from the Magnetic separator tails using a modified form of the Elmore oil process mixing the ore with heavy oil and passing to a spitzkasten where the rock should fall allowing the particles picked up by the oil to float off. The oil seemed to have a selective action on both the pyrite and the molybdenite so that no clean product could be got: besides the larger flakes of molybdenite were not picked by the oil.

The oversize from the 0.20″ screen was treated in a hand jig calculated to give the same results as a Hartz jig. A sample carrying 55 p.c. molybdenite and 45 p.c. mica gave a product carrying 85 p.c. molybdenite with only a small loss as floating particles in the tails owing to a large size of the particles.

A cleaner separation of a similar sample was obtained by treating in a Wetherill cross-belt separator for weakly magnetic material removigg the black mica as a magnetic product leaving molybdenite 90 p.c. pure.

A few flakes of molybdenite go into the magnetic heads owing to imbedded particles of pyrrhotite in the soft molybdenite due to the fine crushing of the rolls. It was found that the imbedded particles of pyrrhotite could be removed by treating in tumbling barrels.

The oversize from 0.10″ screen carrying 48 p.c. molybdenite, 45 p.c, mica with a little hornblende or pryoxene was treated in a hand jig giving a product carrying 70 p.c. molybdenite with a considerable loss as slimes.

Oil concentrating was tried on a similar sample with poor success as the larger particles of molybdenite were not picked up by the oil.

Magnetic separation gave the best results as all the mica. was removed leaving molybdenite 91.10 p.c. pure. The same trouble of magnetic pyrites imbedded in the soft molybdenite was noted.

As molybdenite resembles graphite in many physical characteristics it was thought that a scheme of crushing and treating with Hooper pneumatic jigs such as used in treating flake graphite would give a clean product, but unfortunately the writer had not the use of one of these air jigs. Graphite has a specific gravity of 2.1, while that of molybdenite cannot be separated clean from some of the associated minerals of the same specific gravity. The makers of the Schule dry concentrator successful on the ordinary run of ores report to the writer that they have not been successful so far in removing molybdenite from a gangue of hornblende and mica.

The following scheme of treatment being the result of experiments is probably the most suitable for this ore:—

Hand cobbed ore.
↓
Jaw crusher (0.50″)—Hand picking of large flakes of molybdenite detached.
↓
Rolls (0.20″)
↓
Screen (0.30″)—→oversize—(mica and molybdenite.)
↓
Screen (0.20″)—→oversize (mica and molybdenite also a little rock.)
↓
Screen (0.10″)—→oversize (mica, molybdenite, rock matter.)
↓
Screen (0.05″)—→oversize (mica, molybdenite, rock.)
↓
Wilfley table to save the Pyrite and Pyrrhotite as an ore of Sulphur.

As none of the oversize products from the screens were of commercial grade, experiments were made to ascertain the simplest method of cleaning them.

The oversize from 0.20″ screen was pulverized to pass 0.05″ screen and passed to Wilfley table which delivered a head product assaying 50.4 per cent. Mo and comprising 32 per cent. of the molybdenite in the sample, the remainder escaping into the tails owing to the flaky nature of the ore. Retreatment of the middles from the Wilfley did not yield a clean product so that there will likely be a small loss in treating the oversize products from the screens by the Wilfley which for commercial purposes is probably the best method of cleaning up the oversize products. It is certain that the Hartz jig is not adapted to this purpose. With the object of checking off the results obtained in cleaning up the oversize products by the magnetic separator a sample was sent to the Testing works of the Wetherill Separating Co., New Jersey, and the report as follows shows that this can be readily done although the manager was modest enough to report that the separation cannot be done on a practical basis owing to the high current required and the low capacity of the machine due to the necessary slow speed of the belt-conveyor. Personal observations would lead the writer to believe that the magnetic separator is as cheap and efficient as the Wilfley for cleaning up the oversize products provided a cheap means can be got for removing the embedded

PLATE II.—Showing flakes of Molybdenite (M) in Pyroxene, etc.

pyrrhotite from the larger flake of molybdenite. The smaller sizes of molybdenite do not show the grains of pyrrhotite fastened to the molybdenite so that only the larger sizes will need agitation in tumbling barrels. One advantage of the magnetic separation is that the oversize products do not need regrinding to finer size in a ball-mill as required in the Wilfley table separation.

MAGNETIC SEPARATION OF OVERSIZE PRODUCTS FROM SCREENS.

Separation was made at the testing works of the Wetherill Separating Co., Newark, New Jersey, by George Ernst, assistant superintendent, and analyses by the writer.

Character of ore.—Oversize from screens consisting of molybdenite, pyrite, pyrrhotite, pyroxene, black mica, calcite, quartz.

Object of the test.—To secure molybdenite of commercial grade carrying at least 50 p.c. Mo.

Separator used.—Type E being the Rowand Cross belt machine as shown in plates 4 and 5 delivering magnetic heads, magnetic middles and non-magnetic tails.

Sample A.—Passing through 5 mesh screens to 10 mesh.
Sample B.— " 10 mesh.

Product.	Nature.	Pole Dist. inch.	Amp.	Wt. of product. grams	Size Treated.	Mo in product.	Grade	Extracted.
					p.c.	p.c.	p.c.	p.c.
A 1 Magnetic heads......	Mica, Pyroxene..	½	4	7.5	76.94	0.33	......	......
A2 Non-Mag. tails......	Molybdenite, Quartz, Pyrite........	½	4	2.0	21.06	56.3	93.6	93.4
B 1 Magnetic heads......	Pyroxene, Pyrrhotite .	½	2	3.0	30.00	0.32	......	......
B 2 Magnetic middles....	Mica, Pyroxene..	½	4	6.0	60.00	trace.	.....	.....
B 3 Non-Magnetic tails..	Molybdenite, Calcite, Quartz.....	......	......	1.0	10.00	53.8	89.6	99.4

Sample B consisted of 40 lb. of ore from the Webber property in Victoria County, Ontario, already noted. Plate 2 shows a characteristic sample, the flaky ore being in evidence. The sample carried quartz, calcite, pyroxene, mica, pyrite, hornblende and flakes of molybdenite of different sizes. Red oxide of iron and yellow oxide of molybdenum were found on the surface exposed to weather. The ore crushed, rolled and sized gave the following product:—

1. Hand-picked molybdenite weighing 8 ounces and carrying 55.2 p.c. being 92 p.c. pure.

2 Oversize on 0.30″ screen weighing 2 lb. and carrying 4.58 p.c. Mo equal to 7.6 p.c. molybdenite.

3. Oversize on 0.20″ screen weighing 10 lb. carrying 2.70 p.c. Mo equal to 4.5 p.c. molybdenite.

4. Oversize on 0.10″ screens weighing 2 lb. This sample was included with the fines the total weighing 25 lb. and carrying 1.78 p c. Mo equal to 2.90 p.c. molybdenite..

Oversize 2 was recrushed and screened yielding 1.25 ounces of 90 p.c. ore on the screen.

Oversize 3 was recrushed yielding 5 ounces of molybdenite 91 p.c. pure. All the fines from retreatment of the oversizes along with the fines from first screening were ground in ball-mill finer than 0.05″ and passed to a Wilfley table delivering 10 ounces of molybdenite with pyrite and a little mica being 75 p.c. pure by assay. The middles from the Wilfley assayed 1.60 p.c. Mo and the tails 0.44 p.c. Mo showing that a small quantity was lost.

Altogether 24.25 ounces of molybdenite of commercial grade were saved as a result of the above experiments being about 72 p.c. of the molybdenite in the original sample. No experiments were made with the magnetic separator or oil separation.

Sample C consisted of 20 lb of quartz and red felspar with small flakes of molybdenite scattered through as shown in plate 3. The sample carried 1.5 p.c. Mo equal to 2.5 p.c. molybdenite.

The sample crushed, rolled and sized gave no clean ore on any of the screens so that the whole sample was ground to pass 0.05″ screen. A portion was treated in a Vezin hand jig as it was thought that as the specific gravity of molybdenite being 4.6 while that of felspar is 2.7 a clean separation would be possible in the jig but the flakes of ore seemed to be caught by upward pulsations of water so that no separation was possible.

12 lb. of the sample treated on the Wilfley table gave 1 lb. of concentrated ore carrying 6.84 p.c. Mo equal to 11.4 p.c. molybdenite, being a saving of only 38 p.c. of the value in the ore. This was due to loss as float in the tails as the fine particles of molybdenite seemed to be caught by a slight current of water and carried into the tails.

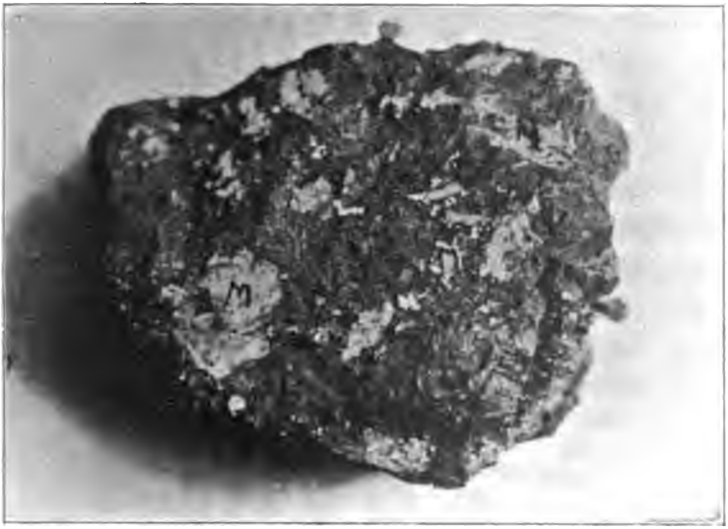

PLATE III.—Showing fine flakes of Molybdenite (M) in quartz.

The molybdenite in the concentrates was readily removed by oil-separation as the selective action was very noticeable.

No constituents of this sample could be separated out by magnetic separation.

Sample D from the deposit in Harcourt Township, Ontario, already noted was examined but resembled sample A so closely that no attempts were made to concentrate it as in all probability it would act the same as A. The small experimental work on these ores have shown that no standard method can be used on molybdenite ores. Each ore is a problem by itself, only to be solved by experimental mill tests.

METHOD OF ESTIMATING MOLYBDENUM IN ITS ORES.

Several methods of estimating molybdenum in alloys and ores have been published and the writer made comparative tests on the different methods the results of which are irrelevant in this paper but will be submitted to chemical journals for publication. The writer devised the following rapid volumetric method for estimating molybdenum in its ores being a modification of the estimation of phosphorus in iron ores by titration with potassium permanganate:—

Mix 0.20 to 1 gram of the ore according to richness with 6 times its weight of sodium peroxide and fuse in a nickel crucible for 10 minutes using a bunsen burner. Caustic potash may be added if the ore is very siliceous. Platinum crucibles must not be used as the peroxide attacks platinum also nickel but the latter is cheap.

The melt dissolves quickly in water acidulated with sulphuric acid, ammonia is added and the solution boiled to precipitate the ferric oxide, etc. Filter, add chemically pure zinc free from iron and sulphuric acid to reduce the molybdic acid to a lower form the clear solution turning an olive brown on reduction, but the reduction should be continued for 10 minutes after the olive-brown color shows in order to be sure that all the molybdic acid is reduced. Filter off excess of zinc with glass wool being careful to allow no particles of zinc to go into the solution. Titrate the olive brown solution to colorless and permanent pink using potassium permanganate standardized for iron or phosphorus. Subtract the amount of permanganate required to make a blank solution a permanent pink. The ratio of molybdic acid to iron is 0.8816 according to Blair's Chemical Analysis of Iron, page 62 and molybdic acid carries 66 p.c. Mo so that Fe value multiplied by 0.666 gives the Mo in the ore when 1 gram is used for analysis.

Van Furman states in his book on Practical Assaying page 102 that the ratio of molybdic acid to iron is 0.9076 but the writer chooses to follow Blair's figures.

All compounds reduced by zinc and sulphuric acid to a lower state must be removed. Among these are iron, titanium, vanadium, uranium, tungsten, chromium. The nickel taken up from the crucible apparently has no influence on the reactions according to blank determinations made by the writer. Qualitative tests were made on the Canadian samples of molybdenite tested showing that iron was the only interfering constituent present in more than traces.

This method was checked off by the electrolytic method which is certainly the most accurate but very slow and concordant results were obtained in nearly every case, although the volumetric method gives low results unless carefully done.

All the estimations of molybdenum given were done by this method which is recommended as a very rapid and quite accurate method.

INDUSTRIAL USES OF MOLYBDENITE AND ITS PRODUCTS.

The mineral molybdenite is the source of the metal molybdenum and the various chemicals used in the arts,

Metallic molybdenum free from sulphur may be made from molybdenite by heating in an electric furnace according to experiments conducted by M. Guichard reported in Comptes Rendues.

The molybdenite used carried—

Mo.......	60	per cent.	Si........	39	per cent.
Fe.......	0.75	"	Si........	0.40	"

Heated in an electric furnace in carbon tubes with a current of 350 amperes and 50 uolts, the sulphur was partially eliminated. With 950 amperes and 55 volts complete fusion was obtained and the sulphur completely driven off. The resulting metal analysed—

Mo........	91.5 per cent.	Fe..........	2.1 per cent.

total carbon—6.9 about ⅙ of the carbon graphitic. A method of making molybdenum electrolytically is described by H. Moissan in *Bulletin de la Societe l'encouragement de l'Industrie Nationale*, June, 1895.

300 parts of molybdic oxide heated with 30 part of carbon in a carbon crucible by an electric current of 800 amperes at 60 volts for 6 minutes, produced the metal free from carbon carrying by analysis—

Mo..99.98 per cent.	Carbon.0.00 per cent.	Slag.0.18 per cent.

Complete fusion of the charge should be avoided to prevent the fused mass attacking the crucible. The metal thus obtained is soft not scratching glass, is easily filed and polished, malleable when hot. It oxidizes at 600° C volatilizing as molybdic oxid even before melting.

Combustion with oxygen produced vivid incandescence. When the reduction of molybdic oxide is made in the electric furnace with an excess of carbon, carbides of molybdenum are formed, the point of saturation being 5.87 p.c. carbon corresponding to the formula Mo_2 C. When saturated with carbon the metal is intensely hard and more fusible than the pure metal.

Pure metallic molybdenum is silvery white in color, has a density of 9 01, is malleable like iron and is readily forged when hot. The pure metal is somewhat infusible, can be filed and will not scratch glass but if heated for some time in contact with carbon at about 1500° C cementation takes place and the metal is very hard after cooling. After the process of cementation it may be be hardened by quenching like steel. A definite carbide, Mo_2 C is known having a specific gravity 8.9 very hard and rather infusible.

The metal, molybdenum, is now being used to make molybdenum steel which is said to be replacing tungsten and chrome-tungsten steels. Tests made by Prof. W. Von Lipin of St. Petersburgh and reported in Stahl and Eisen, 1897, No. 14, showed that the molybdenum steel in a general way but is less effected by tempering and annealing. High heating makes it very hard while annealing makes it softer than the tungsten steels. It can stand heating also tempering in water better than tungsten steel showing no fissures which tungsten steel often shows. It does not break could short as easily as tungsten steel and stands a forging and hardening better.

Experimental work has been done since that date by steel makers but little information is published. It is a well known fact however that tool steel carrying about 4 p.c. Mo is very tough and has the valuable quality of being self-hardening. It is used in shops where machine tools are pushed to their utmost capacity as self-hardening tool steel holds an edge at speeds which would draw the temper all out of carbon steel. Molybdenum steel according to trade reports is now being used to make all kinds of cutters as it can be machined to any shape.

Reports state that the excellent grade of armor plates made by the Krupp Works in Germany carries molybdenum along with tungsten and other rare metals. An excellent grade of steel for armor plates is said to have been made at the Creusot Works in France by using 3 p.c. Mo along with an equal amount of Chromium.

A discussion as to value of molybdenum in steel-making is irrelevant in this paper but for the convenience of those wishing to follow up the subject a list of technical articles dealing with special steels is included in the review of literature.

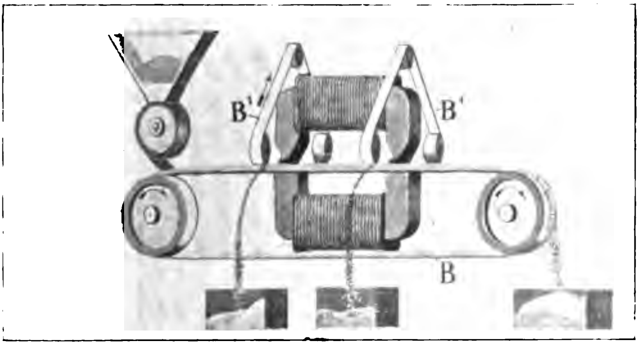

Plate IV.—Reprint of a diagram of the Wetherill Magnetic Separator by F. O. Schnelle, published in a paper read before the Association for the Advancement of Industry (German). This machine separates mica, hornblende and pyrrhotite as magnetic products from molybdenite.

Molybdenum is sold both as the metal, as ferro-molybdenum alloy for use in steel-making.

The best molybdenum is quoted at $1.82 per pound for 96 p.c. pure grade, Ferro-molybdenum (50 p.c. Mo) is quoted at $1.25 per pound.

There are no metallurgical works in Canada producing the alloys nor is the ore mined or shipped except in very small lots but if the demand for the ore continues no doubt some of the richer deposits will be worked. According to official statistics 32,000 lb. of ferro-molybdenum carrying 50 p.c. Mo was produced in the United States during 1900.

About 15 tons of molybdenite were mined in the United States during 1901, but the output for 1902 is likely to be increased.

Molybdenite to be of commercial value must carry at least 50 p.c. Mo and be free from copper. Such ore sells for about $400 per ton but as the market is somewhat limited over production would lower the price. The future of the industry of mining molybdenite depends on the new uses of the metal as the chemical industries absorb only a small quantity made up mostly into chemical re agents and dye chemicals although the use of analine dyes has largely replaced its use in the dyeing industry. A small quantity is used in pottery works for making brilliant blue colors in the glaze.

REVIEW OF LITERATURE REGARDING MOLYBDENITE AND ITS COMMERCIAL PRODUCTS.

1. *Stahl & Eisen*, vol. 22, pages 579–589.—Discusses the making of tool steel for rapid lathe work. A full discussion as to tool steel especially self-hardening and their use in lathe work is given in the same journal, vol. 22, pages 454–456.

2. *Echo des Mines*, vol. 29, page 1197.—Gives a review of the use of ferro-molybdenum as made by electro-metallurgical processes.

3. *Journal of Franklin Institute*, vol. 153, pages 161–178.—Describes the process of making tool steel by Taylor-White method used at Bethlem steel works.

4. *Baumaterialienkunde*, vol. 6, pages 227–229.—A criticism of the Taylor-White tool steel.

5. *Mining Journal*, vol. 72, pages 657–658.—Shows how the metals such as molybdenum are being used in the steel trade.

6. *Zeitschrift des Vereines Deutscher Ingenieure*, vol. 45, pages 1609–1610 also pages 1377–1386.—A full description of quick cutting tool steels.

7. *British Patent*, No. 738 of 1900.—Gives the composition of the

Taylor-White steel showing that it may carry from 1 p.c. to 5 p.c. Mo.

8. *Verhandlungen des Vereines Zur Berforderong des Gewerbfleisses*, 1900, pages 179–189.—Describes the Taylor-White tool steel, and its practical value.

9. *Stahl & Eisen*, vol. 21, pages 169–176 and 215–220.—A discussion of tool steels.

The literature as to occurrence of the ores in Canada are already mentioned. There is practically no literature as to the concentration of molybdenite ores.

Mineral Production, Canada and United States.

By GEORGE JOHNSON, Dominion Statistician, Ottawa.

Tho statistics of mineral production in Canada and the United States for 1901, having been published we have the means of comparing the development of the two countries in the production of mineral wealth.

Both countries classify their mineral production into metallic, non-metallic and miscellaneous, though the officials of the Geological Surveys in both countries differ in their assignments, according to the proverbial saying about our good friends the doctors of medicine.

Let us re-arrange our Canadian list so as to make it correspond with that of the United States Geological Survey, not because the distribution of the Washington savants is any better than the one devised by our own wise men, but simply because there are fewer changes in the selected re-adjustment than would try our patience if we adopted the alternative.

In the general division of metallic, non-metallic and miscellaneous, the value of the production of each country in 1901 was:

	Metallic.	Non-metallic.	Miscellaneous.	Total.
United States...	$524,874,284	$566,351,996	$1,000,000	$1,092,224,380
Canada....... ..	42,309,202	24,103,506	300,000	66,712,703

The first fact that presents itself is the comparative smallness of the Canadian output, just about one-sixteenth of that of the United States. Taken on a per capita basis the United States produce $14.12 per head of their population, and we $12.42, a difference of $1.70 per head. Put in this way the difference does not appear to be so unpleasantly great, Still we do not produce as much per head as our neighbors, although we have as great an area of country and are equally well endowed with mineral wealth. It is some consolation that we are catching up. In 1900 we were short $1.97 per head. This is reduced in 1901 to $1.70. If we make the same relative increase we would produce the same per head value as the United States by 1908. Canada was $6 per head behind in 1891 and only $1.70 behind in 1901. The United States increased its per head output in 1901 as compared with 1891 by $4.20 and Canada by $8.50.

The first column in the above table shows the value of the metallic production of the two countries. This includes antimony, copper, gold, pig iron, lead, mercury, nickel, platinum, silver and zinc and the same in the United States with the addition of quicksilver and aluminum for the latter country.

In the United States this metallic production forms 48.05 per cent. of their whole mineral production while in the case of Canada it forms 63.42 per cent.

In every $100 of mineral wealth produced in the United States $48.05 comes from metallic sources and $51.95 from non-metallic and miscellaneous.

In Canada in every $100 produced $63.42 comes from metallic and $36.58 from non-metallic and miscellaneous.

This was not always the case in Canada, for in 1891 Canada's metallic production was only $29 in every $100.

In 1891 the output of Canada had to be multiplied by 55 to bring it up to the output of the United States, but in 1901, 12½ would be the multiplier, and to that extent Canada has decreased the distance between herself and her big neighbor in respect to metal production. Canada was 55 miles in 1891, and in 1901 she was only 12½ miles, in the rear, at which rate it will not take her long to catch up and pass.

Notwithstanding the large increase in production in the United States—in 1891-1901 over 224 million dollars—Canada has gained upon her neighbour to the extent indicated.

The increase has been, therefore, more emphatic in Canada than in the United States, marked as the development has been in the latter country.

In the United States by far the largest part of the increse is due to the enlarged production of pig iron. In 1891 the production was 8,279,870 tons, and in 1901, 15,878,354 tons, an increase, taking values, of 88 per cent. against a general increase of 64 per cent. in the other articles belonging to the metallic class.

Canada made no such progress in the same period. In 1891 she made $368,901 worth of pig iron, and in 1901, $1,212,113. Relatively this is a greater development than that of the United States; but $46 in every $100 worth of the metal production of the United States was derived from the furnaces which melted the iron ore, while in Canada not more than $2.80 was due to the production of iron.

The equipment of iron and steel works and the encouragement given by the Government in the shape of bounties has resulted in a great development of the production of iron, but the development does not show in the year under review, which is the latest for which the statistics of the two countries are supplied.

In Canada in 1901 very much the largest part of the increase is due to the greater production of gold. In 1891 the gold produced was valued at $930,614 and in 1901 at $24,128,503. In the case of Canada this was 57 per cent. (in 1901) of the total metallic production. In the United States in the same year the gold produced was about 15 per cent. of the total production of metallic substances.

As already stated the United States returns include most of our articles and in addition quicksilver and aluminum, while we have nickel, which appears in the United States returns in very small quantity, if it has any right there at all.

Of aluminum we could produce immense quantities, for we have the material in abundance.

Seemingly we do not need it in sufficient quantities to make it worth while to provide ourselves, and we, therefore, import about $16,000 a year, $8,700 of which is in ingots and the remainder in manufactured forms. The world produces about 6,700 short tons of the value of $3,590,000, and of that the United States has a production valued at $1,920,000, or more than one half.

Of quicksilver the world's production is about 3,470 tons, about one thousand tons of which comes from the United States. Spain and the United States producing about the same quantity. California is the great quicksilver State.

Of tin neither country produces a pound. Canada may have it, but it has not been found. There is a good deal of it needed for the world's uses and whovever succeeds in discovering it in Canada may count upon a fortune following the find. In the meantime we import in various forms about $2,500,000 of tin annually.

Reference has been made to gold and iron as two of the most important of our metals.

The production of gold increased every year for a long time, till 1901, when there was a drop in the quantity.

In 1892 the value was $907,600; in 1893, $976,600; in 1894, $1,128,690; in 1895, $2,083,700; in 1896, $2,755,000; in 1897, $6,027,000; in 1898, $13,775,420; in 1899, $21,261,584; in 1900, $27,908,153, and in 1901, $24,128,503.

The development of the production of gold is of course, primarily due to the discovery of the metal in the Yukon Territory.

Altogether from all sources, Canada has added to the world's store of the yellow metal $160,879,000, of which $70,000,000 or $43 in every $100 have come from the Yukon Territory and practically all of it since 1897.

The production of gold, however, has been developed in other parts of the country. In 1891 the yield of gold in Canada, exclusive of the Yukon, was under $900,000, and in 1901 it was (without the Yukon's contribution) $6,130,000, or a gain of $5,230,000.

In the United States the production of copper stands next in value to pig iron. Its value in 1901 is $6,400,000 more than the value of the gold yield of that year and amounted to $86,630,000. This is over $11,000,000 less than in 1900. The production of copper in Canada in 1901 was $6,097,000, a gain of over $3,000,000 in 1901 as compared with the previous year, and of $4,947,000 as compared with 1891.

Of course in the production of nickel Canada surpasses the United States and all other countries. The chief producers of the world are Canada, Germany and France, in all in the neighborhood of $7,750,000, of which Canada produces $4,600,000. The nickel produced in the United States was under $4,000 in 1901.

The non-metallic division of both Canada and the United States includes fuels, structural material, abrasive materials, chemical materials, pigments and miscellaneous.

Fuels include coal, natural gas and petroleum. Of these in 1901 the United States produced a value of $442,190,754, an increase of 86.5 per cent. over the production of 1891. In 1901 Canada produced $14,581,450 worth, an increase of 78 per cent. on the value of the production of 1891. The production of the United States in 1892 was thirty times more than that of Canada, and in 1901 it was about the same, Canada holding her own.

In 1868 Great Britain produced 115,500,000 tons of coal and the United States 31,500,000 tons. In 1878 the production was: Great Britain, 148,500,000 tons; United States, 57,800,000 tons; 1888, Great Britain, 190,500,000 tons; United States, 148,500,000 tons; 1898, Great Britain, 226,333,000 tons; United States, 219,900,000 tons.

In 1900 the United States for the first time had a greater production; the figures being, Great Britain, 252,000,000 tons, United States, 269,700,000 tons; still further increased in 1901, when the United States production reached 293,300,000 tons, against Great Britain's 245,300,000 tons.

In 1868 the British Isles' production was 36 times that of the United States, and in 30 years (1898) the United States produced within 7,000,000 tons of Great Britain's production.

We have the coal. The demand for it is increasing, and there is no reason why Canada should not be one of the greatest of the world's coal producing countries.

In structural material such as stone, tiles, clay for brick, cement, the United States produced $85,202.715 in 1901, an increase of $15,597,789 over 1900. Canada obtained from her own resources $6,803,756 worth in 1901, as against $6,372,901 worth in 1900. Canada's increase is about 7 per cent.; the United States increase is over 22 per cent.

Among these articles is cement of which Canada uses about

1,100,000 barrels a year. The quantity produced in Canada was 500,000 barrels, the remainder being imported. There has been great expansion in this industry in Canada, and undoubtedly in the near future the demand, which is likely to be greatly increased, will be supplied from home resources.

Chemical materials include borax, bromine, fluorspar, gypsum, marls, phosphate rock, pyrites, salt and sulphur, according to the United States list. Of these our Geological Survey takes cognizance for statistical purposes of gypsum, phosphates, pyrites and salt.

The production in Canada of phosphates is very small. From 31,700 tons in 1890 it has gone down to 1,033 tons in 1901.

The production in the United States in 1901 was nearly 1,250,000 tons, which is an increase over 1891 of 895,000 tons, though between those dates the quantity produced was in many years equal to that of last year.

The exports to the United Kingdom by the United States of phosphates to the value of over half a million dollars in 1901 shows that there is still a market for American phosphates, but there is none for Canadian phosphates. We have abundance. Why did we not hold what trade we had? The reason must be known. Is there anything to be done that will restore this phosphate industry to its former position or must we resign ourselves to abandonment of the business altogether? Seemingly this point will bear investigation. Possibly the application of electricity in the production of phosphorus would give an impetus to the business.

Of sulphur we do not appear to produce any quantity as yet. There was a statement that the companies at Sault Ste. Marie, Ontario, intended to make it from the pyrrhotite ore of Sudbury for use in the manufacture of sulphite pulp for paper making, but the statistical returns do not yet show record in this respect.

Among miscellaneous material may be mentioned asbestus, of which we produced in 1901, 40,217 tons valued at $1,259,759. Of this article the United States produced 747 tons valued at $13,498.

Canada is a maker of arsenic to the value of $41,676, an increase of $18,951 over the previous year. It is produced as a by-product of the gold milling operations by the Canadian Gold Fields Co.

In a general way during the five years 1897-1901 we produced $248,160,323 of articles classed under the heading of mineral production, and we exported in the same period $104,078,270 leaving, for home use about $144,000,000.

In the five year period 1890-94, we produced $92,334,626 and exported $27,677,270 leaving $54,657,356 for our home use.

This would show an increase of 122 per cent. in our utilization of our mineral production,

Of course, considerable of the increase in production is due to the very great development of our gold production. In 1897-1901 we produced gold valued at $93,100,676 against a production in 1890-94 of $5,093,282.

It will be instructive to see how we stand if we eliminate the gold from the exports. The expotrs of 1897-1901 would then be $55,-819,815 leaving minerals to the value of $192,340,608 to represent home used. The exports of 1890-94 would be $25,583,819 leaving $66,780,807 to represent home used. This shows an increase of 188 per cent. in our utilization of our mineral production and points to a very great development in the home isdustries which depend upon the mineral output. It also shows that in various forms and ways we utilize more and more the gold supply of the country within the country instead of exporting it.

Thus in 1890-94 we retained $3,000,000 of our gold product and exported $2,093,000, making a total output of $5,093,000.

In 1897-1901 we retained $44,842,221 and exported $42,258,455 making a total output of $93,100,676.

A wide field of usefulness is offered for many of the minor metals in connection with the electrical furnace. The manufacture of carborundum and calcium carbide in the electro-chemical industries, of aluminum, of sodium, of zinc, of manganese and phosphorus by electrical process, has already attained considerable proportions in Canada without the results appearing in the returns of the Geological Survey.

Volcanic Origin of Natural Gas and Petroleum.

By EUGENE COSTE, E.M., Toronto, Ont.

Three years ago, at the 1900 annual meeting of this Institute, we had the honor to present a paper entitled "Natural Gas in Ontario" (1) in which it was set forth how our strong belief in the volcanic origin of natural gas and petroleum, had induced us to undertake boring operations in a new district of that Province, which resulted in the discovery of the two natural gas fields in the counties of Essex and Welland. In this paper, a few facts and arguments in support of the volcanic origin of these products were advanced by us, but we really then only introduced the subject before this Institute, and we propose now to refer again to this interesting question a little more fully. The importance of the matter scientifically and economically, and the very opposite views to those we champion generally held by most Canadian, American, German, and English geologists, will, we trust, be held by you as sufficient apology for our taking up your time again with this controverted subject, evidently in need of much more light. The necessity of much more discussion on this matter was lately forcibly brought to to our notice by a paragraph in a recent paper (2) of Mr. Robert T. Hill of the United States Geological Survey, in which Mr. Hill said: "In endeavoring to interpret the geological occurrence of oil the geologist is confronted by the fact that science has not yet solved the problem of its origin, which lies at the root of the subject. Among the theories in this field are those of inorganic chemical origin resulting from reaction of one mineral upon another, the generation of oil in leaving microscopic organism such as diatoms and the generation of oil from the decomposition and deterioration of dead organic matter, animal or vegetable, preserved in the rocks. There are facts in nature which can be made to conform to either of these theories, but for the present we must consider oil as a material in the rocks, the origin of which is still unexplained."

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(1) Journal Can. Min. Inst, Vol. III, pp. 68-89.

(2) The Beaumont and other oil fields of Texas. New York and Philadelphia meeting of the Am. Inst. Min. Eng., 1902.

Now we are among those who cannot subscribe to these *terra incognita* statements as to the origin of oil, and, as we will endeavor to show below, we think that science has long ago recorded, and is recording every day, in the newly developed oil and gas fields many facts (among these the valuable records of Mr. Hill himself, in the very paper above quoted) which in our opinion have thrown and continue to throw the clearest light on that origin of the hydrocarbons, whether they be petroleum, natural gas, or solid hydrocarbons.

We will present below a few of these facts under the following heads:

(A). In which we will give examples of carbon and hydrocarbons in ancient plutonic rocks as well as in the present volcanoes, the other associated gaseous emanations of which we will also briefly review, as well as their solfataric phase.

(B). In which we will point out the true analogy of the volcanic emanations and phenomena to the products and conditions found in all the oil and gas fields.

(C). In which we will show the complete inadequacy of all organic theories.

(A). As everyone knows carbon is the fundamental element of the organic world, but this must not blind us to the fact that carbon is also a very important element of the mineral world. Indeed the predominance of carbon in the organic world is one of the strongest evidences that can possibly be adduced to demonstrate its great importance, during past as well as present ages, in the mineral world (including of course the atmosphere) for vegetables and animals alike had evidently no other source to draw from. When one reflects on all the carbon subtracted from the mineral world during the past geological ages by all the representatives of the organic kingdom, especially since the beginning of the Carboniferous, to form not only the coal beds, but the limestones, he must admit that the primitive atmosphere was very rich in carbon.

Therefore large quantities of this element must have been dissolved in the first fluid magma of the earth, and large quantities of it must still exist in the fluid magma of to day under the crust of the earth.

To know and demonstrate in just what form the carbon is there, and how, from it, hydrocarbons were produced, are not essential points, and we will consider it quite sufficient to recall that chemists of high standing in the scientific world, such as Berthelot and Mendeljeff, have long ago (in 1866 and 1877 respectively) suggested very probable forms such as carbides under which carbon could exist in the interior fluid magma, and probable re-actions under which hydrocarbon compounds could be generated. The present great daily production of the hydrocarbon acetylene by the simple action of water on carbide of calcium is very suggestive in that respect, and these considerations together with the further one, now proved and admitted, that eruptive magmas are hydato-pyrogenic, namely contain the more or less notable admixture of water necessary to suggested possible reactions in the formation of hydrocarbons, are sufficient in that respect. We consider that the vital point for us is to actually show the carbon and hydrocarbons in the igneous rocks and lavas proceeding from these internal fluid magmas. That, geology can do and has done, in a great many instances, at points widely distributed over the whole surface of the globe; and, we will now pass in review a few of these instances, namely:

1st. In the Archæan rocks we find carbon under the form of graphite in gneisses, (1) in pegmatite dykes, in granites, (2) gabbros (3) and other rocks, the igneous origin of which is undeniable. In this connection Dr. A. E. Barlow in his excellent report on the Nipissing and Temiscaming region says: "This gneiss though somewhat remarkable in its chemical composition in that it contains cyanite, garnet and graphite in addition to the biotite which characterises it, does not present any evidence whatever either in its microscopic structure or in its field relations of any other than an irruptive origin." In this same volume of the Geological Survey reports, Mr. E. D. Ingall, in speaking of the graphite in gneisses of the Buckingham Township mines, says: "This graphite enrichment always occurs, so far as observed, where the gneiss comes in contact with the massive igneous rocks, such as granites and gabbros. The graphite is not confined to the gneissic bands but often extends into the adjacent rock, as in the case of the "Big Pit" No. 8, of the Walker Mining Co., where it is found most abundantly in a gabbro. In the case of the veins of pure graphite the associated rocks are the same as found with the disseminated ore, namely, rusty gneiss and such igneous rocks as granites and gabbros." In the last mentioned report of the Geological Survey as well as in several reports of Dr. Adams, (1) the association of pyrites with the graphite is often referred to. This association of carbon and sulphur is a constant one in all deposits of igneous origin, as we will have many occasions to show in this paper.

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(1) Dr. A. E. Barlow Geo. Survey of Canada, An. Rep. (N.S.), Vol. X, p. 75 I.

(2) Minéralogie Micrographique. Fouqué et Michel Lévi, Paris, 1879, p. 470.

(3) Geol. Surv. of Can., An. Rep. (N.S.), Vol. X p. 72 s.

We must add here that we are aware that graphite is still regarded by some as a proof of the sedimentary origin of gneisses, but apatite was once thus regarded, before its true igneous nature had been recognised; and, if we add to the above quotations, the fact that Professor Termier, in his thorough study of the eruptions of the Hartz region, (2) has found as much as 3 p.c. of graphite in a gray quartz porphyry dyke cutting across Silurian and Devonian rocks, and that graphite has been repeatedly observed in meteorites, we are sure that we will at least throw doubts on the excellency of graphite as a sure criterion of sedimentation of Archaean rocks.

2nd, In the crystals of igneous gneisses and of most granites (3) and other eruptive rock, gaseous and liquid inclusions are most abundantly found, and these are very often constituted by carbonic acid and hydrocarbons, and also often contain chloride of sodium in solution or in minute crystals.

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(1) Geo. Surv. of Can., An. Rep. (N.S.), Vol. VIII, p. 51 J.

(2) Annales des Mines, 21ème livraison de 1884, p. 307 et 308.

(3) Minéralogie Micrographique, (Fouqué et Michel Lévy.) Paris 1879, pp. 134, 140 et 141.

3rd. Petroleum, or semi-liquid or solid bitumens have often been noticed and cited by many observers as occurring in traps, basalts or other igneous rocks, as for instance, by Sir William Logan (1) in a greenstone dyke at Tar Point, Gaspé, Province of Quebec; by Mr. Rateau (2) in trachytes in Galicia, and by Professor Arthur Lakes (3) in injected volcanic dykes in Archeluta County, Colorado. Other occurences of this kind have been recently described by Mr. Henry M. Cadell, (4) in a paper on the Oilshale Fields of the Lothians as follows:—"In 1890, a diamond bore-hole was made near Little Ochiltree, about one mile North of Binny Craig, which, after passing through the Houston Marl, Houston coal and Fells shale, struck a thick sheet of intrusive dolerite situated near the position of the Broxburn shale. It was noticed that the whinstone core, brought up from a depth of over 600 feet, was cracked in places, and the fissures were full of a soft yellow substance like vaseline or wax which melted in the sun and spread in an oily film over the stone. . . . In the summer of 1900, an intrusive sheet of yellow trap about 3 or 4 feet thick was cut while driving through the shale at the mouth of the Albyn mine, on the eastern outcrop of the Broxburn shale anticline. The trap was full of cavities coated with calcite, filled in the heart with mineral wax, yellowish gray when fresh, and brown after exposure to the air. On analysing the hydrocarbon it was found by Mr. Stewart to consist of:

Carbon, 84-35; Hydrogen, 12.83; Nitrogen, 1.68; with traces of sulphur in some specimens." The above composition is very close to the one of the ozocerite of Boryslaw, Galicia, which is about 85,7 p.c. carbon, and 14.3 p.c. hydrogen. We will yet quote another instance given by Mr. Cadell in the same paper; (5) in referring to a volcanic neck or pipe which was cut through in the underground Broxburn shale working at Gallowscrook near Philpstoun, he says: "The tuff itself varied greatly in character and structure. It was mostly fine grained and light coloured, and was in places excessively hard almost flinty in texture, but when exposed to the weather it soon crumbled down into sandy mud. Here and there it was impregnated with iron pyrites and contained large blocks of black shales and other sedimentary inclusions; or again, it was interspersed with small drusy cavities or veins of pitch or solid paraffin." Describing the beds on the shore of the River Forth, below Hopetoun House, Mr. Cadell says:—(1) "These underlying beds are traversed by a dyke of white or yellowish trap with cavities full of bitumen such as have been noted in the Broxburn district."

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(1) Geology of Canada, 1863, p. 402 and 789
(2) Annales des Mines, 8ième série t. XI pp. 150 152.
(3) Mineral Resources of the U S 1901, p. 561.
(4) Trans. of the Institution of Min. Eng. vol. XXII pt. 3, pp. 347-353.
(5) Loc. Cit., p. 351.

Mr. Cadell, we might add, advances the opinion that in the above cited instances of pitch or solid paraffin in igneous rocks they "are derived no doubt from the distillation of the hydrocarbons in the shale;" but this, we submit, is an impossibility, and, even more, a direct contradiction, as it cannot be imagined that a hot igneous rock, which would distil or drive away the hydrocarbon from a shale, would drive it away into numerous cavities of itself. Then again, if this distillation had taken place in the case above cited of the volcanic neck, the bitumen of the black shale fragments in the neck would also be driven away. Therefor the instances cited by Mr. Cadell cannot be regarded otherwise than as most direct evidence that the origin of the oil of the shales is not intimately connected with the very volcanic rocks, in the cavities of which solid remnants of the oil are still left as witnesses. One, indeed, has only to look at the numerous red spots on Mr. Cadell's map, accompanying his paper, and representing the volcanic rocks and intrusive basalts evidently younger than the oil-shale series, to, at once, understand that this oil district, in which the oil-shale quarrying is going on to-day, was subsequently to the deposition of the shales, subjected to intense vulcanism. During and after this great period of volcanic activity the whole district must have been for a long time permeated by solfataric emanations, coming up through the numerous faults, also shown on the map, and many other minor fissures. No doubt these emanations were composed, as we will see all volcanic emanations are, of chloride, including ammonium chloride, hydrocarbon and sulphuretted hydrogen vapors and gases, and this is clearly how these shales got impregnated with the oil now found in them, and also how the Binny sandstone of that district got its joints and cavities filled with ozocerite or natural pitch. The Balm Well Spring of St. Catherine's, near Burdiehouse in that district, situated on the line of the great Pentland fault, and in the waters of which globules of oil are yet found, the natural gas struck in some of the boreholes near Broxburn, and the bullion Well Spring of sulphuretted hydrogen water rising from a fissure between a volcanic plug and the sedimentary beds are other evidences of this solfataric volcanic action in this district. (1)

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(1) Loc. Cit., p. 359.

4th. Volcanic rocks forming vertical necks and pipes across horizontal strata, and containing carbon in the pure form of diamonds, are also well known to constitute in South Africa the deposits of these precious stones. These diamantiferous volcanic necks and pipes also contain large cavities filled with gaseous hydrocarbon as pointed out by Mr. Moulle. (2) Mr. Moulle cites 17 of these volcanic necks situated all in one staight zone 200 miles long from the Hart River to Fauresmith. He also shows that both the diamond and the gaseous hydrocarbon are found in these necks right in the centre as well as on the sides and under the "reef" or black shales as well as above them, or as well as at the places where the vertical volcanic pipes cross these horizontal black shales, which, here also, are not only not distilled but enriched on the contrary in bituminous matter by the hydrocarbon emanations, gaseous remnants of which are yet found in the workings, in cavities of the volcanic neck.

5th. We now come to the hydrocarbons and carbonic acid in volcanic manifestations of to-day. Not later than a few months ago the civilized world was suddenly startled and horrified at the report that an explosion of Mount Pelée had wiped away in a few minutes the entire population of the City of St. Pierre, Martinique Island. From the accounts of the catastrophe then published, it is quite certain that a fearful blast or tornado of gases suddenly shot from the side of the volcano, asphyxiating and burning in a moment 30,000 people. Nothing else, we submit, but gas could carry death so suddenly to so many thousand people, inside and outside of their houses over a whole city. That these gases were mostly sulphur gases and very inflammable gases (which could be mainly nothing else but hydrocarbons) has also been made quite clear by the accounts of the very few survivors. From among these I will quote the following extracts from the narrative of Count de Fitz James in the New York *Herald*, of May the 27th, 1902, namely :—" Gustave Doré, in his most ecstatic delirium, never conceived anything so dramatic and so awe inspiring as was St. Pierre after it had been desolated by the whirlwind of fire that swept down upon it from Mount Pelée. . . From a boat in the roadstead in front of St. Pierre, Baron Fontenilliat and I witnessed the cataclysm that came upon the city. We saw the shipping destroyed by a breath of fire. We saw the cable ship Grappler keel over under the whirlwird and sink as though drawn down into the water of the harbour by some force from below. The Roraima was overcome and burned at anchor. The Roddam, a trifle more fortunate, was able to escape like a stricken moth that crawls from the flame that has burned its wings and left it a cripple to suffer until death relieves. . . While we were talking, there came an explosion that was beyond anything that ever before happened, I can only liken it to a shot from a mammoth cannon. The breath of fire swept down on the city and water front with all the force that could have been given it by such a cannon. The explosion was without warning and the effect instantaneous. Cinders were shot in our faces with stinging effect. The air was filled with flames, involuntarilaly we raised our hands to protect our faces. I noticed the same gesture when I saw the bodies of the victims on shore. The Roraima was all a mass of flames for several seconds. We could see the poor wretches aboard of her rushing about in the vain attempt to escape from the fire that enveloped them. . . On the shore all was aflame . . . When we gave our attention to the panorama that was spread before us, the entire city of St. Pierre was manteled by a dense black cloud. We could not penetrate it, but it lifted a few seconds revealing below it a second cloud absolutely distinct from it. The second cloud was yellow apparently made up of sulphurous gases. . . Then as the yellow cloud lifted from the earth we saw the flames devouring the city from which all life had disappeared, dissipated by the magic worked by Mount Pelée. Part of Carbet had been struck by the wave of fire from the volcano, but the greater portion of the village was left uninjured.

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(1) **Trans. of the Institution of Min. Eng., Vol. XXII, pt. 3, pp. 350 and 351.**

(2) **Annales des Mines, 2iéme livraison de 1885, pp. 237 et seq.**

To confirm this narrative I will ask your permission to quote the following attributed in a despatch of May 26th, 1902 from Fort de France to Mr. Robert T. Hill, of the United States Geological Survey, who was then studying the volcanic phenomena at Martinique, for the National Geographical Society. In speaking of the great catastrophe in Martinique, Mr. Hill, in this despatch is quoted as saying :—"There were three well marked zones ; 1st, a centre of annihilation in which all life, vegetable and animal, was utterly destroyed. The greater northern part of St. Pierre was in this zone ; 2nd, a zone of singeing, blistering flame which was also fatal to all life, killing all men and animals, burning the leaves on the trees, and scorching but not utterly destroying the trees themselves ; 3rd, a large outer destructive zone of ashes, wherein some vegetation was injured. The focus of annihilation was the new crater midway between the sea and the peak of Mount Pelée, where now exists a new area of active vulcanism with hundreds of fumaroles or miniature volcanoes." From the above quotations, and from other accounts published in the press at the time, we feel quite justified in citing this terrific outburst of Mount Pelée as a wonderful example of the production of large quantities of inflammable gases from a volcano. We mentioned above that these inflammable gases must have been mainly hydrocarbons (probably mixed with hydrogen and sulphuretted hydrogen) and we draw the above inference from the fact that inflammable or combustible gases thus constituted have often been noticed and observed before in connection with many other volcanic eruptions by scientists of great repute, who were actually able to collect and analyse these gases. For instance in the Vesuvian eruption of 1855 56 it was observed by Charles Sainte Claire Deville and Leblanc, (1) that the lava as it cooled and hardened gave out successively vapors of hydro chloric acid, chlorides and sulphurous acid; then steam, and finally, carbon dioxide and combustible gases.

At Torre del Greco, on the sea shore opposite Vesuvius, during the eruption of this volcano of 1861. Mr. Charles Sainte Claire Deville, and Mr. Fouqué (2) gathered and studied the gases from the erupted lava, which was then partly flowing under the sea. The combustible gases from it were collected under water before they could oxidize with the following results, namely :—

	FROM FISSURES OF THE LAVA ON LAND		FROM FISSURES OF THE LAVA UNDER THE SEA.			
			10 to 15 metres from land	40 to 50 metres from land	about 100 metres from land	about 200 metres from land
	Dec. 23	Jan. 1.	Jan. 1.	Dec. 18	Jan. 1.	Jan. 1.
Carbonic acid........	96 32	95 95	88 60	59.53	46.78	11.54
Hydrogen and Proto-Carbon............	3.68	4.05	11.40	40.47	53.22	88 46

As to the above mixture of hydrogen and proto-carbon, Deville and Fouqué found that the further away the sample was taken from the centre of eruption the less hydrogen and the more hydrocarbon there was in it. They also observed that the hydrocarbon gases grew more abundant and marked, especially, the end of the paroxysm of the volcano. For while these gaseous emanations of hydrocarbons were still continuing four years later they had then no more free hydrogen (3)

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(1) A Geikie Geology. p. 200.
(2) Comptes Rendus, t. LXIV, p. 107.
(3) Comptes Rendus, t. LXII, p 1374.

Other gases gathered Jan. 1st, 1862, by Deville, near Santa Maria di Pugliano, from an old fissure formed during the 1631 eruption of Vesuvius and at the exact place where he had observed a "mofette" to declare itself during the eruption of 1855, gave him a considerable quantity of nitrogen mixed with carbonic acid, in the following proportions:—Carbonic Acid, 54,70; Nitrogen, 45.30.

In 1865, Mr. Fouqué (1) during the eruption of Etna, in Sicily, of that year, made similar observations as to the carbonic acid and hydrocarbon emanations from the volcano. An analysis of some of the gases taken by him from Lake Palici, at the foot of that mountain, gave him :—

Carbonic Acid, 93.49; Marsh gas, 1.45; Hydrogen, 0.43; Oxygen, 0.68; Nitrogen, 5 14.

It is also by emanations of hydrocarbons and of carbonic acid, at a temparature varying between 44° Far. and 91° Far., and which were accompanied by salt water and mud andl asted for nine months, that the eruption of Etna of the 9th of May, 1879, was announced. During all this time neither the principal crater nor the secondary one were giving the least sign of activity, but nevertheless, the hydrocarbon vapors were coming out at the southern base of the large come, that is to say very far from the central chimney, between Nicolosi and Paterno, and from small craters one foot and a half to three feet in diameter, and arranged along a north and south fissure. (2)

At Santorin, in the Greek Archipelago, in the series of eruptions which lasted from January 1866 to October 1870, Mr. Fouqu repeatedly observed and gathered under the water gaseous mixtures proceeding from the lava of the volcano very rich in cumbustible gases, and containing sometimes as much as 30 p.c. of free hydrogen, and this last gas was all the more abundant when the lava was hottest. Free oxygen was sometimes mixed uncombined with the hydrogen. Sulphuretted hydrogen gas with the protocarburet of hydrogen were also obtained together, and these cumbustible gases, coming out between incandescent blocks of lava, would burn with blue and red flames. In 1875, five years after the end of the four years of the above mentioned eruptions, emanations of gas and vapors were still active on the southern part of Nea, one of the little islands of the Santorin group. (1)

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(1) Mémoire sur les phénomènes chimiques de l'Eruption de l'Etna en 1865.

(2) A. De Lapparent—Traité de Géologie, Paris, 1883, p. 414.

(3) Santorin et ses éruptions, Paris 1879.

From observations made in May, 1878 at Vesuvius, Herr Siemens has been led to conclude that vast quantities of hydrogen gas or combustible compounds of hydrogen exist in the earth's interior, (2) and no doubt this conclusion would have been more often reached by other observers were it not that the very inflammability of these hot gases as soon as they come in contact with the air precludes their being easily recognized. Nevertheless the presence of hydrocarbon gases in volcanic emanations on account of their petroleum odour was conjectured by DeBuch, Ferrara, Poulette, Scrope and Hoffmann; and, according to Serrao, Dolomieu and Ferrara, blocks of scoriæ freshly ejected by Vesuvius showed district traces of naptha. The existence of these cumbustible gases in the fumaroles explains the volcanic flames, which have been seen by La Condamine, Humboldt, Boussingault, Bory de St. Vincent, Soufflot, Verdet, Deville, Fouqué Janssen and others; they are due to the combustion of hydrogen sulphuretted hydrogen and carburetted hydrogen. (3)

Before leaving this subject of the combustible gaseous products of the volcanoes, we desire to draw particularly your attention to the associated vapors and gases emanated by them from and with the interior fused lavas, namely:—what has been called the "dry fumaroles" always emanate from the lava itself near the centre of the lava flow, the temparature is above 500°C. and they are almost entirely composed of anhydrous chlorides, principally chloride of sodium of which as much as 94.3 p.c. has been found in the gases from Vesuvius. Other "fumaroles" called "acid fumaroles" have a temperature varying between 300° C. and 400° C., and are a mixture of hydrochloric acid and sulphurous acid with enormous quantities of steam. Finally the "cold fumaroles," the temperature of which is under 100° C., contain with the steam and hot water about 5% of carbonic acid and considerable hydrogen sulphide, which, in decomposing, forms deposits of sulphur (1).

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(1) A. De Lapparent Géologie, p. 430.

(2) A Geikie; Geologie, p. 53.

(3) A. De Lapparent Géologie, p. 413.

We will further draw your attention, to the phenomena observed in the volcanic districts, where the volcanoes themselves have been dormant either for a short period or for many years, or where they may be considered extinct altogether. In this region of dormant, or extinct volcanoes, the interior energy still manifests itselt through gaseous, steam, and hot water emanations, exactly similar to those we reviewed briefly above. This is the well known and most important solfataric phase of vulcanism which may be only momentary, as the active volcanic force may burst out suddently in a new paroxysm, or it may continue with gradually diminishing force to finally die out altogether, but not without leaving first profound and distinct marks and impress of its former existence. In this last case the gases, vapors and water emanations will often continue to be emitted, not only for many years, but for many centuries, from the volcanic vent itself or from its vicinity, first as steam and sulphurous vapors, or as hot and boiling springs, and then as emanations at a much lower temperature, charged principally with hydrogen sulphide and carbon gases. The two first are the "solfataras" and "geysers," while the last category constitutes the continuous of the "suffionis," the volcanic hot springs, the "salses" and the "mofettes." Each one of these forms of the dying volcanic activity differs somewhat from the preceding one, but they are nevertheless so intimately connected one to another, and so intimately connected often with the active phases of vulcanicity, that the internal origin of their products is as clearly evident as in the case cited above, where the gases were found to form intimate mixtures with the fused lavas themselves from which they were collected and analysed.

It is not necessary to our subject to refer at greater length to the

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(1) A. De Lapparent Traité de Géologie, p. 411.

"solphataras," and "geysers," but we must say a few words on the "suffionis," the "salses" and "mofettes." In the "suffionis" of Tuscany, the steam jets, 30 to 40 feet high, are arranged in groups along fissures; the condensed waters containing boric acid form also deposits of sulphur and gypsum. Carbon dioxide is in preponderance in the gaseous emanations of these "suffionis" with sulphuretted hydrogen in notable quantity; hydrocarbon gases mixed with free hydrogen are also present as recognized by Charles Sainte Claire Deville (1). The "salse" are numerous in the Appennine region of Italy where several have from time to time showed renewed signs of activity, (2) such as the "salse" of Sassuno which had a paroxysm in 1839, uplifting the rocks around its mouth; its gaseous mixture includes with the protocarbon a carburet of hydrogen richer in carbon; in 1839 black bitumen was emitted. The "salses" of Sassuolo (3) in that same region has had a number or paroxysms already mentioned by Plinus, and renewed again in 1660, 1789 and 1835. A very large quantity (ten million cubic meters) of mud and stone were ejected at this last period, and was soon covered with efflorescences of salt. Not far from Sassuolo, at Mount Zibio, petroleum springs have been known from all ages.

In Auvergne, in the centre of France, at the foot of the volcanic chain of the "Puys" a spring of bitumen comes out of the Puy de la Poix," and if one remembers that there are very abundant emanations of carbon dioxide in that extinct volcanic region, at Clermont and Royat for instance, and that the volcanoes there rest entirely on the granite, the proof is conclusive that the carbonic acid gases and liquid hydrocarbons marking the last sign of the. volcanic energy in that region are of deep, internal origin.

At both extremities of the Caucasus Mountains, at Taman and Kertch, between the Black sea and the Sea of Azof, and at Bakou on the Caspian Sea, powerful mud volcanoes have been known for centuries, and they are often associated with large quantities of natural gas and petroleum. The Apcheron peninsula, near Bakou, is of volcanic origin, as eruptions of lavas and projections of stone yet take place from time to time; the height of the mud volcanoes there is very great, some being as high as 1,300 feet. Rivers of oil have been known to boil out from under the Caspian sea, and often explosions of burning oil have taken place naturally, throwing up in the air masses of clay and stones. These explosions have uplifted the bottom of the sea and have lately given rise to small islands in the vicinity of Bakou (1).

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(1) A. De Lapparent, Géologie p. 490.

(2) Fouqué, Revue des Deux Mondes, 1 Avril 1871.

(3) A De Lapparent, Géologie p. 490.

The "mofettes" or carbonic acid emanations, with or without water, are so well known in so many dormant or extinct volcanic districts, such as those near Naples at the "Grotto of the dog," and at other points in the vicinity; those in the Eifel region where more than a thousand have been counted; those of Auvergne and the Vivarais in France; those of the valley of Death in Java, etc., that this mere mention is sufficient here, and we wish to point out that there can be but little doubt, from the table of analysis made on the gases collected from the lava on land and under the sea, at Torre del Greco near Vesuvius, by Deville and Fouqué. and given above, that these "mofettes" or carbonic acid emanations are the result of the oxidization of hydrocarbon gases from the interior fluid magma.

To resume this very imperfect review of the volcanic gaseous emanations, we will ask your permission to make another short quotation from professor A. De Lapparent, he says:—" Volcanic phenomena, from the violent paroxysm to the simple "mofettes," form a continuous and admirably ordained series agreeing in all points with the succession of emanations during a single eruption. Though a few local variations it is always the same law of decreasing energy which from the hot chloride emanations leads through sulphurous ones to the carbonic acid ones with predominance of the combustible gases at the places where there has been no oxidization."

(B.) We now pass to our second paragraph in which we propose to show that all the petroleum, natural gas and bituminous fields or deposits cannot be regarded as anything else but the products of solfotaric volcanic emanations condensed and held in their passage upward in the porous tanks of all ages of the crust of the earth from the Archaean rocks to the Quaternary. Nothing is so simple and therefore nothing so natural as this origin, and we will see that it can be abundantly proven. We will divide the data and proofs we propose to induce for this under the following heads: —

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(1) A. De Lapparent Traité de Géologie, Paris, 1883, p. 490.

1st. Direct proofs and rock pressure of natural gas.

2nd. Complete analogy of the products of the oil and gas fields with the products of volcanic solfataric action.

3rd. Location of the oil and natural gas fields along faulted and fissured zones, each one presenting a few particularities of its own, similarly to the systems of volcanoes and to the mountain chains of the globe.

4th. The oil, natural gas and bitumens are never indigenous to the strata or formations in which they are found; their "sands" or other deposits are nothing more than natural rock tanks ranging in geology from the Archaean to the Quaternary, and these products must therefore come from below the Archaean.

5th. Oil, gas and bitumens are stored products, in great abundance in certain localities, while neighbouring localities often are entirely barren, exactly as volcanic products would be and the strata in which they are found are so impervious that it forces one to the conclusion of a source, with powerful energy, directly below their fields.

1st. To the direct proofs given above of solid, liquid and gaseous hydrocarbons in lavas or other igneous rocks, or in emanations cleary volcanic, can be added direct proofs of vulcanicity from a few of the oil and gas fields, and these will serve as a link as it were between the volcanoes, on the one hand, and the oil and gas fields where the volcanic origin is not so plainly apparent, on the other.

We have already mentioned above on the high authority of Professor A. De Lapparent, the direct volcanic manifestations in the great Russian oil fields near Bakou from which it is quite evident that the source of the oil is there volcanic. Hot waters and hot gases in connection with some of the other oil deposits of the Caucasus Mountains have also been mentioned by Mr. Leproux. (1)

But, on this continent, in the newly discovered oil fields of Texas and Louisiana, and also in the California fields, we have many no less direct evidences of vulcanism, though they do not appear to have been understood in their true light. These are, in Louisana and Texas, the Salt Islands and the "Mounds" of the Coast Prairie, such as the famous "Spindletop," near Beaumont, which are clearly nothing else but "suffionis" or "salses," hardly extinct yet, grouped along fractured lines (2) and marking in that region the dying out of vulcanicity, that is to say the dying distant echo of that tremendous volcanic energy, which a little further south, in Mexico, Central America, and inthe islands and along the south coast of the Caribbean Sea, is to this day so powerfully active.

In this connection, Mr. Robert T. Hill, in his paper above quoted, (3) points to a very significant fact, through in our opinion it has a different meaning to the one he gives to it, when he says:—"It is an interesting fact that asphalts and oils rich in asphaltum occur in terrigenous (land derived) sediments of the nature, age, and general character of the East Texas Eocene, around the entire perimeter of the Gulf of Mexico, and the Caribbean Sea. The asphalts of Tamaulipas in Mexico, Vera Cruz, the Isthmus of Panama and Cuba, as well as the great asphalt deposits of Trinidad, Barbados and Venezuela, all come from beds of this character."

We claim that there is much more indicated by the occurrence of these asphaltum oils along the weak, faulted and broken volcanic margins of the Gulf and Caribbean Sea, and that the terrigenous sediments, not only Eocene, but of many other ages, are simply the sandy tanks which happened to be there and which their sandy nature, due to their terrigenous origin, made porous enough to be able to hold the gaseous, liquid and solid products of the abundant, but spotted, volcanic emanations of that region including not only natural gas and liquid asphalt oils, but also much hydrogen sulphuret gas and large deposits of these eminently volcanic products, sulphur and salt. Abundant proofs of the above statement are to be found in Professor Robert T. Hill's paper, already twice quoted, and to us these proofs are so conclusive that you will pardon us if we again quote copiously :—

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(1) Annales des Mines, 11ième livraison de 1892, pp. 526, 528.

(2) Am- Inst. Min. Eng., Trans. XXIX, Capt. Lucas, p. 463.

(3) Am. Inst. Min. Eng., N. Y. & Phila. Meeting, Fed. and May, 1902, p. 38.

" In the generally monotonous monoclinal structure (of the Coast Prairie of the Gulf) there are a few wrinkles or small swells likely to escape the eye of even the trained observer, and yet of a character which may have an important bearing on the oil problem. These are the circular and oval mounds, already described, which were first recognized by Capt. Lucas. When he pointed out Spindletop hill to me, my eyes could hardly detect it; for it rises by a gradual slope only ten feet above the surrounding prairie plains. I was still more incredulous when he insisted that this mound, only 200 acres in extent, was an uplifted dome. But Capt. Lucas said that I would be convinced of the uplift if I could see Damon's mound in Brazoria County. In August, 1901, I visited that place, and returned for a second look at Spindletop, and was convinced that, if these hills are not recent quaquaversal uplifts no other known hypothesis will explain them. Damon's mound is an elliptical hill, a mile or more in greater diameter, rising 90 feet above the surrounding level. . . . The salt islands of of Louisiana were described by Capt. Lucas in the transactions of the American Institute of Mining Engineers before his discovery of oil at Beaumont (1). These so called islands, rising from 80 to 250 feet above the surrounding marshes of the Coast Prairie, are hills beneath layers of stratified clay and sand. They belong to the same group of topographic phenomena as Spindletop hill at Beaumont. By sinking through the super-structure of sand and clay Capt. Lucas located the salt bodies, and determined their horizontal extent, developing also the important fact that, though limited in diameter, they were of great depth, that of Jefferson Island having been penetrated for 2,100 feet without reaching bottom. . . . The bodies of salt discovered beneath the hills of the Coast Prairie are of remarkable size, thickness and purity, notably those of Louisiana, and one discovered within the past few months at Damon's mound which, for its lower 700 feet, is pure rock salt with occasional traces of oil. . . . It was Capt. Lucas who discovered the relation between the sulphuretted hydrogen fumaroles, gas springs, and sulphur incrustations at the surface and the bodies of subterranean oil; and it was his belief in this association that led him to seek for oil on Spindletop hill (1) . . . . The oil is closely associated with the mounds, occuring on their slopes or summits. . . . In some localities hot water has been struck below the oil. . . . In the original Lucas well, the oil itself is hot. . . It had a temperature of over 110°F. The oil seems to occur not in any definite continuous stratum but in spots of many strata. Gas in immense quantities and frequently under such pressure as to the wreck the wells, has been struck before reaching the oil. This has occurred several times at Spindletop, twice at Sour Lake, and once at Velasco, where the destructive effect was terrific. Sulphur and Sulphuretted hydrogen gas occur in intimate association with the Beaumont oil. In fact, the oil itself is said to contain 1 to 2% of sulphur, and the fumes of sulphuretted hydrogen are strong in the vicinity of the wells . . . . Underground bodies of sulphur associated with the oil by natural processes have been found in many localities. The Calcasieu section of Hilgard shows at 540 feet in depth solid sulphur rock similar to that encountered at 1040 in the Beaumont well. At Damon's mound a bed of sulphur from 10 to 40 feet thick was encountered above the salt. Crystals of free sulphur also occur in the cap rock overlaying the Spindletop oil. Capt. Lucas found the sub-stratà of the south eastern part of Belle Isle, above and down to the rock salt, were heavily impregnated with petroleum. Several calcareous strata containing sulphur were also encountered. . . The wells at Damon's mound encountered small flows of oil at depths of from 400 to 600 feet. . . . At Keyser's mound, in the same county, about six miles north of Damon's. and near the Brazos River, a flow of oil was struck at about 400 feet. . . . Still another interesting phenomenon is the occurrence of dolomite. The oil of Spindletop is said to occur in a cavernous mass of this material. At Big Hill, Jefferson connty, which is one of the most conspicuous of the mounds, the drill after going down 300 feet penetrated a mass of coarsely crystalline dolomite in which it continued to nearly 1375 feet. At 900 feet a small seep of oil was struck in the dolomites."

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(1) Transaction Am. Inst. Min. Eng., XXIX pp. 462, et seq.

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(1) The same relation was shown by us in our paper before this Institute 3 years ago. [Journal Can. Mining Inst. Vol. III, pp. 87 and 88.]

Nothing could be more suggestive to us than the above quotations when we remember the volcanic phenomena which we reviewed in the first part of this paper. Mr. Robert T. Hill calls the association of oil, sulphur, sulphuretted hydrogen gas, gypsum, dolomite and salt, in the so called mounds or island of this region, " the oil phenomena " but it hardly needs this new name as we see by Mr. Hill's own description of it that it is clearly a well known part of the old volcanic phenomena, so clearly that Mr. Hill himself unconsciously uses the word " fumarole " in describing it.

In his last report on petroleum in the Mineral Resources of the United States, (1) Mr. F. H. Oliphant confirms the true nature of these mounds, as here indicated, in this significant remark :—" The depth of the wells to the productive bed vary from 880 feet, about the centre of the elevation at " Splindletop," to 1190 feet near the edges of the productive area, indicating that the stratum holdiug the petroleum is in a general way conical, conditions which seem to be verified by the deep wells, less that 500 feet from defined territory, failing to find any trace of the open cellular carbonate of lime and pure sulphur structure encountered on the mounds, at depths of over 2000 to 2500 feet. The thickness of the oil bearing formation is placed by different drillers at from 20 to 75 feet. It is almost pure carbonate of lime with more or less combined sulphur as well as surrounding crystals of pure sulphur."

To the volcanic solphataric phase of phenomena these mounds, or rather as we see, real vertical chimneys, must surely belong. How else could be explained their hot oil, their hot water, and especially their vertical chimney like masses of sulphur, salt, limestone and dolomite permeated and impregnated with natural gas, oil and hydrogen sulphuret gas? Is it not a well known fact, as we have seen in the first part of this paper, that all these products associated together are the essential characteristics of the solfataric phase of vulcanism?

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(1) United States Geol. Surv., Mineral Resources of the U. S., 1901, p. 568.

Mr. Hill has attempted to explain his so-called "oil phenomena" by the following hypothesis "offered with hesitation" as he says himself: "The oil and salt pockets of the Texas Coastal Plain are probably not indigenous to the strata in which they are found, but are the resultant products of columns of hot saline waters which have ascended, under hydrostatic pressure, at points along lines of structural weakness, through thousands of feet of shale, sand and marine littoral sediments of the Coastal Plain section, through which oil and salt are disseminated in more or less minute quantities. The oil, with sulphur, may have been floated upward on these waters, and the salt and dolomite may have been crystallized from the saturated solution."

The main point of that hypothesis, namely the hydrostatic pressure, is, we submit, absolutely disproved by the simple fact that the "Spindletop" wells are now already pumping wells instead of gushing flowing wells as they were when first struck:—an hydrostatic pressure behind them would be constant, and would continue to make them flow now as at first, especially if it was "a tremendous hydrostatic pressure" as Mr. Hill says it must be.

This simple evidence then is conclusive that the saline waters, oil and gases under these mounds are not under an hydrostatic pressure.

We beg to submit also that carbonated and oxidized meteoric cold waters descending and permeating through the sediments of the Coastal Plain would condense and fix oil and sulphur in these strata from hydrocarbon vapors and sulphuretted hydrogen gases diffusing through them from beneath, but would certainly not do the reverse, namely, gather and float these upward as proved by the barreness in oil and sulphur of the artesian springs mentioned by Mr. Hill to the westward. The fact that, at Marlin, the water, from 3200 feet only, has a temperature of nearly 140° F, and is excessively saline and sulphurous is to us only another proof of the expiring vulcanism of that region, and of the admixture of hot emanations from below into the decending water at that place, as the normal rise in the isogeotherms alone could never account for that temperature in circulating descending waters.(1) That water cannot diffuse through sedimentary strata carrying mixed with it and gathering small quantities of petroleum, as also suggested lately by Geo. I. Adams, (2) is fully indicated, as remarked by Dr. David T. Day, in his discussion of Mr. Adam's paper, by the fact that "the diffusion of crude petroleum through fuller's earth and shales is accompanied by a partial separation of the constituent oils." "*A fortiori*," would oil and water promptly separate in diffusing through sediments, especially if the water was meteoric and oxidized, when the oxygen and the low temperature of these waters would surely, as shown in many springs, condense aud fix oils from gaseous hydrocarbons and also sulphur from sulphuretted hydrogen gas.

Then again, where does the oil, salt and sulphur come from, which according to Mr. Hill's theory are disseminated in abundance in the sediments from the Ordovician to the Post Eocene of the Texas section, and which, under his hypothesis, are now carried by these artesian waters and become the source of these products of the mounds? It is evident that the question of origin is not solved by Mr. Hill's hypothesis, and that it is only put back and shirked as it were. Why should that be done when the fact of a volcanic solfataric origin, as developed by the phenomena of these mounds, is so glaring? If these glaring facts are not seen and recognized, then "*a fortiori*," it will be impossible to know from where the oil, more or less disseminated through the whole Texas section, comes from; and, it is no wonder that the claim is made that science has not yet solved the problem of the origin of oil.

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(1) In this connection see Prof. Kemp in Trans. Am. Inst. Min. Eng., vol. XXXI, p. 191 et seq.

(2) Principles controlling the geologic deposition of the hydrocarbons, N.Y. and Phila. meeting of the Am. Inst., Min. Eng. 1902 and discussion.

If we now transport ourselves from Texas to the Island of Trinidad, at the other end of the circle of oil and asphalt deposits, which, as it as been remarked, border the Gulf of Mexico and the Caribbean Sea, what do we find there? According to Edward W. Parker, (1) of the United States Geological Survey "the chief source of the supply (of asphaltum) is a lake of pitch filling the crater of an extinct volcano. This lake lies 138 feet above the sea level, and has an area of 114 acres. The supply is being partly renewed by a constant flow of soft pitch into the centre of the lake from a subterranean source." The solfataric volcanic emanations at Trinidad are also abundantly attested by the many mineral springs of that Island, by the strong thermal waters with borates, iodides and sulphur compounds intinately mixed as an emulsion with the bitumen of the pitch lake; by the gas issuing from the cracks in the bitumen; and by the indurated clays, burnt red shales and porcelanites to the southward of the lake (2).

If we now transport ourselves to California we find that through all the extensive oil fields of that country, situated along the Coast Range, which has been only recently uplifted, the solfataric volcanic phemonena are most abundant to this day in connection with the oil deposits which are found in very disturbed and dislocated strata of the Cretaceous, Tertiary and Quaternary. Here, the shales, interstratified with the bituminous and oil sands, have become reddened and burnt, bleached to white shales, and changed to porcelanites by the solfataric vapors, and they have also been greatly calcified and salicified by the hot calcareous and silicious waters. Hot natural gas and hot sulphuretted hydrogen emanations, as well as hot and boiling waters, issue yet from the hot ground in a number of places as at the Calera Rancho, six miles west of Santa Barbara, where, on the ocean shore, an area of twenty acres has lately subsided some 25 feet, and from the hot ground of which heavy petroleum oil oozes out with sulphurous and other vapors and hot saline waters. Mr. A. S. Cooper, (3) State

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(1) U. S. Geol. Surv., 21st An. Rep., part VI p. 327.

(2) California Mines and Minerals, San Francisco, 1889, p. 143-144.

(3) The Genesis of Petroleum and Asphaltum, by A. S. Cooper, California Mines and Minerals, p. 114, *et seq.*

Mineralogist of Califortia, in a paper on "the Genesis of Petroleum and Asphaltum" devotes a great deal of space to these red burnt and white bleached shales as connected with the genesis of bitumen in California, but he attributes the evidences of heat and heated vapors and steam everywhere shown by them to chemical heat engendered in the shales themselves in some mysterious way, or generated in some even more mysterious way in the metamorphic rocks below the Cretaceous.

This "chemical heat," according to Mr. Cooper, distils the carbonaceous vegetable matter in the rocks and the resultant gas, oil and asphalt migrate upward into the Cretaceous, Tertiary, and Quaternary rocks to fill there the gas and oil sands and to form the asphalt veins.

But why this "chemical heat" should have been so accommodating as to have waited until the Tertiary and Quaternary formations were deposited before mėtamorphosing and distilling these lower formations is not clearly explained. Nor does Mr. Cooper give any reason why this "chemical heat" has not also distilled into gas, oil and asphaltum the coal beds and lignites of the Cretaceous and Tertiary. Until these facts are more clearly explained and the mysterious cause of the "chemical heat" is also established, we will persist in seeing in the prolific "oil phenomena" of California, accompanied by so many evidences of the so called "chemical heat", direct proofs of the intervention of the solfataric phase of vulcanism, which phenomena are, and were, evidently connected here with the orogenic uplift of the Coast Range.

There remains now one more direct proof of vulcanicity in the oil and gas fields to which we desire to especially draw your attention. This proof is general and present in all the oil and gas fields, and therefore of primary importance in a consideration of the origin of oil and gas; we refer to what has been called the rock pressure of natural gas. This great force, which often has thrown out of a well high above the derrick an entire string of tools weighing thousands of pounds, and which often gushes the oil and the pebbles of the oil sands, with terrific force, hundred of feet high in the air, cannot be explained in any other way than as a remnant or spark of the initial volcanic energy, the stupendous force of which in volcanoes has so often caused most tremendous explosions, appalling in their magnitude and effects, blowing out enormous craters and sometimes whirling out without warning, as from the mouth of a mammoth cannon, a destructive tornado of inflammable and irrespirable gases over a whole city, as in the recent memorable instance of St. Pierre, Martinique. In some of the oil and gas wells this pressure of the gas has registered as high as 1525 lbs. to the square inch, or over 100 tons to the square foot, but it is generally considerably less, and ranges ordinarily between 200 lbs. and 1000 lbs. in fresh fields when first struck, at depths of from 500 ft. to 3000 ft. It varies greatly in the different fields from wells of the same absolute depths, even though the two fields are not far distant, as for instance in the case cited by the late Professor Edward Orton, (1) where a well in Oswego County, New York, only gave a pressure of 340 lbs. to the square inch from a depth of 2100 feet, at which the gas was struck in the Potsdam sandstone, while another well in Onondaga County, N. Y., the "Munroe" well, where the gas was struck in the Trenton limestone at 2370 feet, gave a pressure of 1525 lbs. to the square inch. But, and this is a very significant fact which indicates plainly the internal origin from below, in the same field when gas is found in different strata, as it very often is, the strongest pressure is always in the lowest stratum, and the rate of decrease of that pressure from the lowest stratum to the upper ones is very irregular, evidently depending on the more or less open channels of communication between these strata which existed at the time of the solfataric volcanic activity under that field, channels which have now long ago been closed up as a rule. The other significant fact of the rock pressure of natural it is a continually decreasing pressure from the time the gas first used in a new field. until finally it is all exhausted. This shows, without a doubt, that there is nothing now behind that pressure. no hydrostatic column or anything else; the gas possesses the energy,

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(1) Bull. Geol. Soc. of Am., vol. 9, p. 92-95.

per se, it is its own life, and it imparts it to the water, or to the oil, sharing the sands with itself to make them flow violently at first, but before long this decreasing pressure becomes powerless, and the oil has to be pumped. This would not be the case if a constant hydrostatic head was behind it; therefore, this fact alone is enough to condemn absolutely Professor Orton's and Professor White's theory of hydrostatic or artesian water pressure as an explanation of the rock pressure of natural gas. We refer you to our former paper before this Institute (1) for figures showing that the pressure of the gas in the Welland County field of Ontario is not in any way imparted by an artesian water pressure. As I also remarked in this paper the Paleozoic oil and gas rocks of North America are far from being porous enough to form permeable sheets arranged in basin from between impervious layers and with porous outcrops, and thus never fulfill all the conditions necessary to constitute artesian basins. These rocks, ranging in geology from the Potsdam all the way to the Pittsburgh sandstone just above the Pittsburg coal, have in many cases furnished oil and gas sands forming in shale series irregular bodies, unconnected and without outcrop. In this case, how can anyone seriously adduce an artesian water pressure to account for the rock pressure of the gas? But, even in the case of the Trenton limestone, which is a thick continuous stratum with long outcrops to the north, and forming a basin under Ontario, it is far from being pervious enough, and therefore some of the conditions for an artesian basin are not there, as absolutely proven by a number of wells which were drilled right through the whole series down to the Archaean below, and never found any water. Even at Collingwood, where the Trenton limestone outcrops under the town and under the Georgian Bay, a number of wells, drilled there, have found only sulphurous and saline waters in small quantities below 130 feet; and, three wells which were drilled under the Mountain, fifteen miles south of Collingwood, pierced the whole Trenton limestone, from 1160 to 1750 feet, without finding a drop of water in it, though the top of the Trenton in these wells, situated miles one from the other, was about 275 feet below the level of the Georgian Bay in each instance. Where is Professor Orton's artesian water column here? wanting absolutely, right where it should be on the track between Ohio and the outcrops of the Trenton. It is only fair to add here that Professor Orton, himself, in his presidential address (1) read before the Geological Society of America, Dec. 28th, 1897, abandoned as untenable his theory of artesian water pressure as the source of the natural gas rock pressure. Yet, there is surely a cause for these great pressures, going up sometimes as high as 100 atmospheres, recorded by natural gas. If it is not a volcanic energy, what is it? Svante Arhenius, (2) the distinguished Swedish physicist, has figured out that the crust of the earth is solid down to about twenty-five miles, and that at this depth, where the temperature must he 1200° C. and the pressure about 10840 atmospheres, commences the fluid magna; also that, at the depth of about 186 miles, the temperature must without doubt exceed the critical temperature of all known substances, when therefore the liquid magma must pass to a gaseous magma subject to extremely high pressures. Here then, only twenty-five miles, at most, below the gas fields, is an adequate source for the natural gas pressures, and this is the only adequate source we can possibly find. We also know that light hydrocarbon or natural gas is emanated abundantly in all the volcanic regions from these interior masses. We therefore have, there below the crust, and there alone, the source of both the natural gas and of its strong energy and life called rock pressure.

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(1) Journal Canadian Min. Istitute, Vol. III, p. 85.

2nd. Complete analogy of the products of the oil and gas fields with the products of volcanic solfataric action.

It is well known, and our brief review in the first paragraph of this paper shows, that the great volcanic solfataric products are water, chloride salts, sulphur, sulphuretted hydrogen, carbonic acid and hydrocarbons with often an admixture of hydrogen, oxygen and nitrogen.

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(1) Bull. Geol. Soc. of Am., Vol. 9. p. 99.

(2) Zur. Physik des Vulkanismus (Geol. Fören Förh.), Stockholm, 1900.

That all oil and gas fields in every part of the world present the above products in a remarkably constant association, though of course occasionally a few of them may be missing, is a fact so well known that it is unnecessary for us to do more than refer to it briefly. We have already seen, that in the case of the Texas and Louisiana fields this association, mainly, of salt, sulphuretted hydrogen, sulphur, and hydrocarbons is most pronounced. So it is clearly in the Lima oil fields, including the Canadian fields, and in the California fields.

But, even in the Appalachian fields of New York, Pennsylvania and West Virginia, where the oil is free from sulphur and the gas is generally free from sulphuretted hydrogen, yet it is not always so and sulphur waters are very often found in the wells of that region almost as generally as salt waters which are constantly associated with the oil and gas. This occasional presence of sulphur in the oil and gas at a few places along tha Appalachian belt, especially in New York State, where it is found in lower formations, confirms Dr. David T. Day's suggestion that, if as a rule the Pennsylvania oil and the Lima oil differ in their sulphur contents and color, it is probably due to a filtering process which the Pennsylvania oil has been able to undergo in its passage upward through Devonian and Carboniferous fine-grained shales and sandstones. The following table of analysis which was published in Professor Edward Orton's geology of Ohio, volume 6, page 137, eloquently demonstrates that every one of the products which characterises volcanic gaseous emanations is present in the natural gas of Ohio and Indiana, except water and chlorides, and these are to be found abundantly in the salt waters always accompanying the gas and oil.

GAS.	Table of Analysis of Natural Gas from Ohio and Indiana						
	1	2	3	4	5	6	7
Hydrogen	1.89	1.64	1.74	2.35	1.86	1.42	1.20
Marsh gas	92.84	93.35	93.85	92.67	93.07	94.16	93.58
Olefiant gas	0.20	0.35	0.20	0.25	0 49	0.30	0.15
Carbonic oxyde	0.55	0.41	0.44	0.45	0.73	0.55	0.60
Carbonic acid	0 20	0.25	0.23	0.25	0.26	0.29	0.30
Oxygen	0.35	0.39	0.35	0.35	0.42	0.30	0.55
Nitrogen	3.82	3.41	2.98	3.03	3 02	2.80	3.42
Sulphuretted hydrogen.	0.15	0.20	0.21	0.15	0.15	0.18	0.20
Localities	1.—Fostoria, Ohio. 2.—Findlay, " 3.—St. Mary's, "			4.—Muncie, Indiana. 5.—Anderson, " 6.—Kokomo, " 7.—Marion, "			

In all the European and foreign oil fields, without exception, the same association, mainly of salt, sulphur and hydrocarbons is constantly found; we will only cite one more instance of this, here; but in Russia, Sumatra, Java, Japan, China, etc., in every field, it is always the same. About the associated minerals in the oil fields of Galicia and Roumania along the Karpathe Mountains, Mr. Rateau (1) says "the characteristic accessory materials in the petroliferous strata, are besides petroleum and salt, gypsum, native sulphur, and several sulphides, namely, zinc blende, pyrites and galena. Frequently also sulphurous springs with much free sulphuretted hydrogen are struck. These strata along the Karpathe also often contain, in cavities, large quantities of the following gases; hydrocarbons and carbon dioxide and sometimes sulphuretted hydrogen and sulphurous acid. These gases are under very strong pressures, going up into the ten of atmospheres,"

This fact that the oil and gas fields always furnish the same associated, though diversified products, as given out in the volcanic regions is unquestionably one of the strongest possible evidences that could be adduced to demonstrate the vulcanicity of the oil and gas.

3rd.—Location of the oil and gas fields, and of the solid bitumens along faulted fissure zones, similarly to the system of volcanoes, and to the mountain chains of the globe.

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(1) Annales des Mines, Sième série, t. XI. p. 154.

Few geologists are to be found to-day who do not admit, at least, a liquid sub-stratum under the solid crust for the constitution of our planet, be the centre of it gaseous, liquid or solid; and who do not also recognize the cooling and shrinking of this interior fluid mass as the grand cause of vulcanicity including not only all the direct volcanic phenomena but also all the dislocations, movements, faulting and fissuring of the crust of the earth, except possibly some local and minor displacements. The mountain chains therefore, and the volcanoes stand out as the chief results of one profound cause in which the entire mass of the whole sphere is in operation. It is only natural then to find the mountain chains and volcanoes of the earth in such long straight lines marking the much faulted and fractured grand circle zones of least resistance of that sphere. But in the resulting effects, on the earth's crust, of the pressures causing these great orogenic and volcanic dislocations, we must expect to find all degrees of intensity from the immense parallel folding, fracturing and faulting, so grandly illustrated in so many of the great systems of mountain chains, to numerous zones much less dislocated and fractured, generally parallel to the neighboring mountain range or to some main offshoot of it, and in some cases possibly hundreds of miles away from it, and marking the progressively dying out efforts and effects of that particular great orogenic revolution from the mountain chain outward. These minor fissured and fractured zones may be of such slight disturbances and fracturing that this fact may hardly appear, especially when the surface is largely drift covered. Yet, the pent up gases and vapors of the interior may during the active period or periods of these disturbances have succeeded in forcing their way up along these zones to or near the surface. Even in North America, where so much deep drilling for oil and gas has so long ago taken place, several of these disturbed and fractured zones have only been indicated in the last few years in the drilling operations connected with new discoveries of oil or gas. Such was the case in the North Western Ohio gas and oil fields as shown by the late Professor Edward Orton (1) in these words:—"Up to a recent date it was not known that the underlying rocks failed to share the monotony of the surface, but the explorations of the last two years have revealed the surprising fact that the rocky floor of the Black Swamp of old time is characterized by far greater irregularity of structure and by far greater suddeness and steepness of dip than the strata of any other portion of Ohio. The entire floor of North Western Ohio including the Lake Counties, as far east as Lorain County, is seen to lie in a disturbed and uneasy condition. . . The Findlay break is abrupt and well marked, and is indeed the most remarkable fact in the structural geology of Northern Ohio. The occurence of petroleum and gas, but especially of the latter, in North Western Ohio, has been found to be associated with greater irregularities of structure than are known elsewhere in the State, except in a single locality. It is in Findlay that the most marked disturbance occurs, and the great supplies of gas that are found there appear to be closely connected with this disturbance."

In our paper "Natural Gas in Ontario" (2) we pointed out two faults, established by the drilling, in the Essex County, Ontario, gas field, one to the North and the other to the West of the "Coste Well No. 1.," and we have no doubt that the gas in that field came up along these faults.

Mr. Robt. T. Hill in his paper on the Beaumont oil fields, previously referred to, says:—"There is some evidence that the Coast Prairie overlap conceals a line of serious deformation, which may be a sharp fold, with an increased dip coastward, or a zone of faulting." Concerning this same region Mr. E. T. Dumble (3) says:—"While the Coastal Plain is now just what its name implies, during Tertiary times, it was subjected to oscillation, accompanied by certain phenomena which marked the dying out of vulcanism in this region."

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(1) Geology of Ohio, vol. VI. p. 46 et seq.

(2) Journal Can. Min. Inst. vol. III.

(3) Am Inst. Min. Eng. Mexican meeting 1901—Discussion of Capt. Lucas paper on "The great oil well near Beaumont."

In the theory, which he formulates to explain "the oil phenomena" of the Texas mounds, Mr. Hill suggests that artesian saline waters bring up the sulphur and oil along this indicated line of faulting in that region; we simply go a little further and claim that this line of faulting gave access to volcanic emanations bringing the water, salt, sulphur. oil and gas from the interior in the state of vapors and gases, which condensed more or less near the surface, some escaping yet in their gaseous state as the hydrogen sulphuret and the natural gas.

In the famous Appalachian oil and gas belt bordering and following the Appalachian Mountains from the Eastern shore of Lake Ontario to Alabama, for the distance of 900 miles, the evidences of parallel folding, faulting and fracturing are most numurous, as shown in the report and maps of the Pensylvania, Ohio and West Virginia Surveys, and, if so many anticlines, slopes, synclines and terraces have proven to be good oil and gas fields all through this vast extent of country, and from rocks ranging from the Potsdam sandstone to the Upper Productive Coal Measures, it is certainly not because these hydrocarbons have moved sideways to the anticlines (as we will see below they cannot do on account of the imperviousness of the strata) but because this region being, at certain geological periods, a dislocated and fractured zone, the hydrocarbons have then moved upward from below through these faults and fissures. This is plainly evidenced by the solid vertical core of hydrocarbon at the Ritchie Mine, Ritchie County, West Virginia, where a straight vertical fissure, 4 feet wide in the sandstone, but much smaller and more irregular in the shales, is completely filled with a mineral pitch or inspissated petroleum, called Grahamite, by Wurtz, (2) and first described by Professor Leslie (1) in 1863, and lately fully reported on by Geo. H. Eldridge (2) of the United States Geological Survey, who seems to admit, with Professor of the West Virginia Geological Survey, that the source of the Grahamite is the oil in the Cairo sand 1300 feet down, but, that does not explain the source of the oil in the Cairo sand which, we will see, can be traced to below the Archaean. Therefore, the Ritchie Mine Grahamite vein, though only badly defined when traversing the shales must, nevertheless, have extended at one time to below the Archaean.

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(1) Am. J. Sci, 1886 ii. xiii, 420; Proc. A. A. A. Sci, xviii, 124.

(2) Proc. Am. Phi. Soc. IX., 185.

The great Burning Springs, Volcano, Horse Neck and Eureka "break" of West Virginia, in the vicinity of which the oil and gas deposits of that State were first exploited, on account of these products coming up near the surface near the "break," is another strongly marked evidence of the dislocations which have affected the oil and gas rocks of the Appalachian belt.

A great many similar evidences of dislocation and fracturing can be cited in other oil and gas fields or in solid petroleum or bitumem deposits, which, like the oil and gas fields, have been shown to be also local impregnations along zones of great fracturing, evidently connected with orogenic uplifts:—such as the Ten Mile, Page, Fourche, Buckhorn and Brunswick districts in Indian Territory and Arkansas. In his valuable and very full account of the asphalt and bituminous rock deposits of the United States, Mr. Eldridge (5) fully describes the connection of the bitumen deposits of the above districts with Ouachita Mountains and Arbuckle Mountains uplifts, in the vicinity of which they occur, in zones of great folding and faulting; for instance, of the Brunswick district, he says:—"The Brunswick district of bituminous rocks, one and a half miles square, lies immediately North of Rock Creek, four miles North-East of Dougherty. The topography is rough, developed in strata highly crumpled and faulted. The structure is a part of that involved in the Eastern end of the Arbuckle uplift."

Similarly, as reported by Dr. Bailey, (6) in the "Albertite" district of New Brunswick," the rocks of the Lower Carboniferous formation show evidences of profound disturbance, being very generally tilted at

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(4) The Asphalt and Bituminous Rock Deposits of the U.S., 22nd Ann. Rep. U. S. Geol. Sur. p. 232.

(5) 22nd Ann. Rep. U. S. Geol. Sur.

(6) Geol. Sur. of Canada, 1876-77 p. 354, et seq. and vol. X (N.S.) p. 68 M.

considerable angles, while at many points they are nearly or quite vertical. These softer beds in most instances exhibit numerous and abrupt corrugations, while both they and the coarser sediments are broken by numerable faults and dislocations." Cutting every fine-grained dark gray to black shales of these disturbed Lower Carboniferous rocks, the hydrocarbon "Albertite" is there found filling a strong vertical fissure, as much as seventeen feet wide in places, which was mined to a depth of 1,300 feet; and filling also numerous branch veins in the enclosing rocks. It was also found in the underlying Pre-Cambrian metamorphic slates, in the overlying Coal Measures and forming veins and irregular masses in the pure white and stratified gypsum of the Hillsborough quarries, all of which shows the injected character of this hydrocarbon from below the Pre-Cambrian slates. A little natural gas and petroleum, as is well known, is associated with the "Albertite" in that district, and the Albert shales are often very bituminous, showing that instead of being drained to form the Albertite vein, they have been on the contrary impregnated and filled with petroleum from the numerous fissures and faults of that district.

In Utah, the Uintaite (Gilsonite) district, as shown by Mr. Eldridge (1) occupies a fractured zone in the middle of the Uinta synclinal basin sixty miles long from the Colorado-Utah boundary to Fort Duchesne, and some forty miles wide. In this zone many parallel vertical veins of Gilsonite, from one-sixteenth of an inch to eighteen feet wide, and from a few hundred yards to eight or ten miles long, have been found running North-West and South-East in the general direction of the mountains. In this same general direction to the South-East, sixty miles on the other side of the Colorado-Utah boundary, oil is now being found at Debeque, on the Denver and Rio Grande Railroad. This Gilsonite zone, containing a number of most powerful veins in every way similar to metallic veins, filled with hardened petroleum, is to us most suggestive and illustrates grandly how the oil and gas sands, of the oil and gas belts have been filled from below with their hydrocarbons. To suppose that these powerful Gilsonite veins are mere cracks stopping in the shale series below, namely, the Green River shales, from which the oil drained into the veins, as Mr. Eldridge does, seems to us impossible as the closed texture of the shales would surely not permit this drainage which, on account of the great quantity of Gilsonite in some of the veins, would necessitate the drainage of an immense area of fine grained sediments, and the friction would not permit it. On the contrary, the powerful energy of highly pent up gases from the volcanic reservoir below, alone, could furnish the necessary pressure to drive the hydrocarbons through the poorly defined, shattered, and almost entirely closed up portions of the veins through the shales. Besides, if these so called cracks only extend to the Green River shales, where does the oil in these shales come from?

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(1) Loc. cit.

Similarly, the oil fields of California belong to much disturbed and fractured belts bordering the Coast Range on each side for 650 miles. There also, the migratory upward movement of the hydrocarbons through fractures of the strata is most plainly attested by the numerous asphalt veins, and by the tar and gas springs (1). And at several places there, in Santa Cruz district, and near King City, in the Galivan Range, the bituminous sand rock rests directly on the granite (2) plainly showing that the fissures must extend through the granite to the only possible source of the bitumen underneath. If there is much less gas in the California fields, and if the oils are as a rule considerably heavier than along the Appalachian belt, it is no doubt due to the much more disturbed and fractured state of the strata, as well as to their more unconsolidated conditions, which permitted the light oils to escape. Each separate zone or belt of the oil and gas fields will thus show difference with other belts, not only on account of the volcanic solfataric products which in general are likely to be the same along the entire length of the one belt and will on the contrary vary somewhat from belt to belt, but also, on account of the dissimilar geological and physical conditions of the strata from one belt to the other.

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(1) A. S. Cooper, California Mines and Minerals, p. 120 *et seq.*

(2) Geo. H. Eldridge, 22nd Ann. Rep. U. S. Geol. Survey.—The Asphalt and Bituminous Rock Deposits of the U S.

In the foreign oil and gas fields we find exactly the same phenomena, namely, the dislocated and fractured belts along the mountain chains furnish the oil and gas fields, as grandly exemplified, in the case of Galicia and Roumania, along the Karpathe Mountains, where the oil fields, following in that mountain range, turn in a grand sweep of more than 500 miles from a north-west to south-east direction in Galicia, to an east and west one in Roumania. There also, the deposits of solid petroleum, or ozocerite of Boryslaw, Galicia, illustrate the mode of deposit, and the source of the oil which in its more fluid state of oil and gas is never so apparent and so easily made out as it is in its solid state. The large mining developments by shafts and galleries in the ozocerite deposits of "Boryslaw" (furnishing several millions of dollars worth of it annually) have shown conclusively that the solid petroleum exists there in veins cutting the strata in every direction, but the most important and principal veins, from which evidently the other are derived, are parallel true faults. Mr. Rateau (1) and Mr. Babu (2) have each published interesting papers on the Boryslaw Ozocerite in the "Annales des Mines" and Mr. Babu concludes as follows,—"The principal faults have brought up from below the hydrocarbon emanations which have filtrated through existing fractures and saturated porous sandstones; the nearer to these faults the richer the deposits." These faults Mr. Babu says,—have the direction of the mountain range North 50 degrees West and are true "paraclases" of Daubré.

As to the Russian oil fields, they are, of course, no exception to the general rule, being situated on much dislocated and fractured zones on each side of the Caucasus uplift, from the Tamansk Peninsula in the North-West to the Apcheron Peninsula in the South-East, 750 miles apart. For further evidences of this we will refer you to Mr. Leproux's (3) report already mentioned. The same association of naphtha to a dislocated zone along the Kurdestan chain in Persia has been well described by J. De Morgan. (4) Finally, we will close the evidence under this head, by mentioning that Japan, Javas, Sumatra, Borneo and Peru are all well known volcanic regions, and that they constitute also to-day the other principal foreign oil fields, thanks, also, to the dislocated and fractured state of their strata along parallel belts to the main volcanic chains of these regions.

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(1) Mr. A. Rateau, Annales des Mines, 8ième série, t. XI.
(2) M. L. Babu, Annales des Mines, 8ième série, t. XIV, p. 69.
(3) Annales des Mines, 9ième série, t. II, pp. 522, 532.
(4) Annales des Mines, 9ième série, t. I.

4th. The adventitious character of gas, oil, and bitumen in any and all the strata in which they are found is a most easily proven proposition; in fact, it is a self evident proposition when the ever present strong pressure of natural gas is remembered. Such elusive fluids, ready to gush out with such a force the moment the drill pierces their reservoirs, and evidently ever impelled upward through disturbed, faulted, and fractured strata, by the strong pressure of their gas, can never be in their original home, and the evidences that they are not is most abundant. In our paper "Natural Gas in Ontario" we gave a table, which we reproduce here, with the Cambrian oil rocks of Newfoundland added.

PALEOZOIC OIL GAS "SANDS" OF EASTERN NORTH AMERICA.

Pittsburg sandstone just above the Pittsburg coal.					
Fifty foot Macksburg sandstone	160	feet below	the	Pittsburg coal	Lower Carboniferous and Subcarboniferous.
First Cow Run or Joy Sand	240	"	"	"	
Mahoning sandstone	300	"	"	"	
Middle Cow Run or Freeport sandstone	410	"	"	"	
Upper Second Cow Run sandstone	600	"	"	"	
Lower Second Cow Run standstone	650	"	"	"	
Tionesta, Homewood or 700 feet Macksburg sandstone	810	"	"	"	
Upper Connoquenessing or 800 feet Macksburg sandstone	910	"	"	"	
Lower Connoquenessing or Upper salt sand	1000	"	"	"	
Lower salt sand or Sharon Conglomerate or Olean Conglomerate of Maxon sand	1050	"	"	"	
Keener sandstone	1200	"	"	"	
Big Injun sand	1280	"	"	"	
Squaw sand	1350	"	"	"	
Berea grit	1700	"	"	"	

First sand or Butler Second sand or Gantz		**Upper Devonian white sands**
100 foot rock		
50 foot rock		
Second sand or thirty foot rock		
Blue Monday sand or Gordon		
Boulder sand or Hickory		
Stray third sand		
Third sand		
Fourth sand		
Fifth sand		
Elizabeth sand		
Warren slush oil sand		**Middle Devonian**
Warren third sand		
Clarendan third sand		
Speechley sand		
Cherry Grove and Sheffield sand		
Cooper oil sand		
Bradford oil sand		
Lower Waugh and Porter sand		
Elk County group of sands, two or three in number.		
Hamilton limestone	**The Petrolia and Oil Springs, Ont., upper show**	**Lower Devonian**
Corniferous limestone	**Oil Springs and Petrolia fields**	
Oriskany sandstone	**Euphemia Fields, Ont.**	
Guelph limestone	**At least three different horizons in Essex and Welland Counties**	**Silurian**
Niagara limestone	**Seneca Falls, Aiden, New York State and in Indiana**	
Clinton limestone	**At Lancaster, Ohio and Welland Co , Ont.**	
Medina red sandstone	**Two different horizons in Welland Co. and in New Yovk State**	
Medina upper white sand	**Welland Co., Buffalo, Alden, Oswego & Onondaga Counties**	
Medina lower white sand		
Trenton limestone, upper part	**Several horizons in Ohio and Indiana**	
Trenton limestone, lower part	**Several horizons in Welland Co and Oswego and Onondaga Counties, N. Y.**	
Calciferous & Potsdam sandstone	**St. Catherines, Ont., Oswego and Onondaga Counties, N.Y.**	**Cambro-Silurian**
Quebec group	**Newfoundland**	**Cambrian**

The above table shows more than 50 different "sands" (by this term we mean any gas or oil rock, as in the parlance of a driller, whether it is a sandstone, a limestone, or any other rock) in which oil or gas fields have been found along the Appalachian belt, and we have no doubt that as a great many so called "stray sands" were left out of the table and, as the different "pay" or "pay streaks" of the same "sand" are only counted as one, that the real number of different sands which have been found containing gas or oil along this belt, from West Virginia to New York State, cannot be less, if any, than eighty. Let us take you along this belt in a rapid survey of what the drill really teaches us:—in the oil region south-west of Pittsburg the drill starts (where the upper measures are the thickest) in the Upper Barren Coal Measures, and inside of 3,500 feet to 4,000 feet passes through the 26 oil and gas "sands" of the Lower Carboniferous, Sub-carboniferous and Upper Devonian shown in the above table; but, here it will tap the illusive oil or gas in one of these sands, there in another, in the most indiscriminate fashion. Occasionally, it will tap them in the same field in two, four, six or even more of the "sands" like at Macksburg. Which is going to be the producing sand? is always the question. Will it be the shallow or Cow Run sands? or the Salt sands? or the Keener, Big Injun or Berea? or the deeper Gordon or 5th sand? It is quite evident that the oil and gas are wanderers, and that their home is not in any of these sands. We now go north-east of Pittsburg to the Middle and Northern oil fields:—here, a good many of the upper strata of the south-west have outcropped (the general dip being south) and the drill starting, we will say, on the Upper Mountain or Salt sands will reach the Elk County group of sands in about 3,000 feet. Here, the Cow Run sands are gone, and the Salt sands, Big Injun and Berea, are too near the surface, and therefore as a rule not productive any more, though they were among the big producers of the south-west; and the drill finds the oil and gas (in the southern part of this district) in the Venango-Butler oil group:—the same oil, the same gas, in the same sands as in the deeper strata of the south-west. Then further north, in and around the famous Bradford field, these Venango-Butler oil group "sands" are in turn too near the surface, and the drill to find oil or gas has to descend lower into the Middle Devonian dark sands. Who doubts that it is the same oil, the same gas, and that the home of the wanderers is not located yet? Let us continue the survey of our drill still further north. We are now in N. Y. State and we start say in the Lower Devonian about 500 feet above the Corniferous limestone :—we will reach the Archaean rocks after going through in the average about 4,000 feet of strata. Here, all the prolific oil sands of the other districts to the south-west have outcropped but, for all that, our drill goes down and finds oil and gas in the Corniferous, in the Niagara, in the Clinton, in the Medina, in the Trenton, and finally in the Calciferous and Potsdam. Who doubts but it is the same oil and the same gas, and that our drill is still searching, near the bottom of the stratigraphic scale, for the home of our wanderers ? No one will argue that the Potsdam sandstone constitute this home. We have then at last reached the Archaean crystalline floor without finding this home and, on the top of it, we record the highest pressure for the gas yet recorded namely :—1525 lbs. to the sq. inch, at the Munroe well, of Onondaga County, N. Y., above referred to. Our gaseous wanderer has still some life left in him, in fact he seems to have more the nearer we get to its source ? Now ! what is that source ? It is evidently not the Archaean below, for we know, without the shadow of a doubt, that the Archaean rocks were crystallized, or "metamorphosed," as many geologists call it, ages before the 10,000 feet of sedimentary strata we have just drilled through were deposited, and therefore any distillated products from Carbonaceous matter in the Archaean would have been lost in the air long before our oil rocks were there to receive them. Our negative proofs then become a most positive conclusive proof that the home of our wanderers is below the Archaean in the fluid magma. This conclusion, which the drill along the Appalachian belt teaches us, is emphasized by the evidences in all other oil regions :—in Texas, for instance, Mr. Hill shows, in his paper previously referred to, (1) that the oil sands range from the Ordovician to the Upper Tertiary ; in California, Mr. Cooper has shown that they range from the Lower Cretaceous to the Quaternary, some of them resting right on the granite. (2)

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(1) The Beaumont and other oil fields of Texas. American Institute of Mining Engineers, New York and Philadelphia meeting, 1902, p. 14 et seq.

(2) 22nd An. Rep. U. S. Geol. Surv. 1901—Eldridge—The Asphalt and Bituminous rocks deposits, p. 369, 404 and 408.

In the Indian Territory along the Ouachita and Arbuckle mounttains the strata are impregnated with bitumen, not only in the Cretaceous, but in the Coal Measures, and also in the Ordovician—(3) a very great stratigraphic range of thousands of feet of sediments—showing the common source of origin of the bitumens from below. Finally, not to tire you out with too much repetition, we will only further mention the Russian fields, where oil and gas pools have been found from the Jurassic to the Quaternary. (4) Surveying therefore this question in the different fields all over the world, as one must do to arrive at the truth, instead of looking only at the oil in a diatom, we find the wandering, elusive oil and gas in the sands of all ages above the crystalline floor of the Archaean, and we even find "Albertite" in that crystalline floor in King County, N. B. (5) We therefore wonder why so many geologists are always looking for the "horizon" which has given berth to the oil or gas of this or that particular field, for evidently there is no such "horizon," and we have only to do in every case and in every field with natural rock reservoirs or tanks to which the American drillers have given the characteristic name of "sands."

5th. Another and last proof which we want to adduce is that the petroleum and natural gas deposits are such locally separated and accidental accumulations, often in such very large quantities, that their source must be from the deep seated vulcanic reservoir directly beneath, which, alone, is abundant enough, and was powerful enough, to force such large quantities of hydrocarbons through most impervious strata during periods of volcanic activity under these fields. In discussing the origin of petroleum and natural gas, the mistake has often been made to suppose and admit that certain "horizons," especially of shales, are entirely "bituminous" over very large areas and are to be found spreading out uninterrupted, like coal beds for instance, over wide regions. In fact, in most of the papers which we have read discussing this subject, some more or less extensive, bituminous shale horizon, sometimes situated above, strangely enough, is always pointed at as the source of the oil; but, that, of course, as we have already remarked does not solve the question of origin :—it only defers it, and shirks it, as it were. But futhermore, we submit, that the evidence to be gathered in all the oil and gas fields shows how localized and accidental the deposits of these products are and that in no case do they form widely and uniformly spread "sheets." Carbonaceous shales sometimes form such "sheets" but not bituminous shales. Hunt (1) has long ago denied that the so called bituminous shales, "except in rare instances, contain any petroleum, or other form of bitumens." These two words "carbonaceous" and "bituminous" are very far from being synonymous, and this fact has been so often lost sight of. But even when shales are really bituminous (that is contain hydrocarbons) they contain these only in spots, as well illustrated in the oil shale fields of Scotland, where in the different quarries different beds of shales, occupying a series under the coal 3,000 feet thick, are worked, the same bed not being found rich or "impregnated with oil," in more than one locality or two. (2)

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(3) Eldridge Loc. Cit., p. 262 et seq.

(4) Leproux—Annales des Mines, 9ème série, tome II, pp. 523-532.

(5) Dr. Bailey, Geol. Sur. Canada, Rep. 1876-7, p. 390. An. Rep. N.S., p. I6 T.

We have seen above how well the mounds and the salt islands of Texas and Lousiana illustrate this localization of oil and gas deposits in a few small spots, here and there, with extensive barren stretches of the same formations between; and that the abundance of the oil, obtained from under little "Spindletop," at Beaumont, is so remarkable that it entirely precludes the admission of an indigenous source from the sedimentary strata under, or near, this mound.

The evidence to be deducted from the hundreds of small separate pools found by the drill during the last forty years in the Appalachian oil belt is no less conclusive in showing the spotted nature of these deposits, notwithstanding that the many sands or strata in which they are found often continue uninterrupted between these different pools and beyond, but there they are found quite barren of hydrocarbons over areas scores of times larger than those covered by the oil or gas pools. Then again, the oil region of Pennsylvania is altogether confined to a certain zone or belt in the western part of the State and all the central and eastern parts, though also underlaid with fossiliferous strata, are barren of hydrocarbons. But the facts here lead us yet to another important conclusion when we further remember, as previously noticed, that often different pools, quite near and in the same "sand," have different rock pressures, that the oils themselves often differ considerably from one pool to the other, and that in the same field two "sands," only separated by about 125 feet of strata (as the Clinton and Medina "sands" of Welland County, Ont. (1), showed original rock pressures varying 125 pounds to the sq. inch, we will then clearly realize how impervious, even to highly pent-up gases, the Paleozoic strata of North America are, and how it is that all these numerous neighboring pools, in the same district, do not communicate one with the other. This is further strongly exemplified by the fact that many oil and gas pools have been found with strong rock pressures only a few hundred feet down and quite near the outcrops of the producing sands. How then can it be argued that oil and gas which, in these conditions, cannot escape to the surface, could have travelled long distances sideways, upwards and downwards through the strata, to accumulate on a distant anticline, from disseminated organic remains spread far and wide in some fine-grained shale strata where surely no sufficient force or pressure could originate to overcome the countless frictions bound to take place in this long travel? These long travels through the pores of such impervious strata, especially without a strong impelling force behind, are absolutely impossible. Therefore oil and gas must have come from immediately below their fields, through fractures and faults, but not from the sedimentary strata below these fields which could not possibly produce, from a limited fossiliferous area, either the quantity of these products, or the rock pressure of the gas. We are thus forcibly led to the deep volcanic source for the origin of oil and gas from where we know that abundant hydrocarbon vapors emanate and where alone the energy is sufficient to drive these up through such impervious strata.

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(1) Essays, p. 169.

(2) Heary M. Cadell, Trans. of the Institution of Min. Eng. vol. XXII, part 3, pp. 316 et seq.

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(1) Journal Can. Min. Inst., Vol. III., p. 68-89.

Even this tremendous interior energy which, as mentioned above, has been figured up into the ten thousands of atmospheres, or 150,000 lbs. to the square inch, had evidently all it could do to force the hydrocarbons, and other associated gases and vapours up to so near the surface, and yet not out altogether; and this was only possible and accomplished during special periods of activity producing faulting and fracturing. This wonderful impermeability of the sedimentary strata of the oil regions was well recognized by J. P. Lesley (1) and John F. Carll (2) of the Pennsylvania Geological Survey, and also by the late Professor Edward Orton (3); and,- when properly understood, we submit that this impermeability is one of the strongest proofs of the vulcanicity of petroleums, gas and bitumens, as explained above.

All other fields show the same spotted and local feature of impregnation in their petroleum deposits. Even in North-Western Ohio and Indiana, where the oil and gas stratum is a limestone and where therefore solfataric waters could partially dissolve and dolomitize this limestone, thus rendering it more porous, and spreading the subsequent oil and gas deposits more than usual, yet even there the 250 million barrels of oil, and the enormous quantities of gas, which have been obtained in the last 16 years, have been produced from very limited areas in these States, though in many other counties of these, and adjoining States, the same fossiliferous stratum, viz.: the Trenton limestone, has proven barren of hydrocarbons, nothwithstanding that the organic source (if such there was) would be available there just the same as in the neigboring oil fields, as well as many anticlinal domes and other varieties of flat structure which have been regarded as necessary and sufficient to the accumulations of oil and gas travelling through from fossil sources.

The Berea grit of Ohio affords us another most striking example of the localization of oil and gas pools. Notwithstanding that it underlies most uniformly 50 counties of Ohio and 20,000 sq. miles (4) and that it overlies the greatest shale formation of the entire State, viz, the Ohio shales, ranging in thickness from 300 to 2,000 feet and that it is covered by some 400 feet of impervious shales, viz, the Berea and Cuyahoga shales, yet it is only productive of oil and gas at a few points. How is it that since, as Professor Orton said:—"There is everywhere underlying the Berea grit an abundant source of oil" (the shales) and that, since the impervious cover is mostly always there over this vast territory protecting a good, continuous, often porous, sandstone reservoir, that in point of fact, as Professor Orton also said (1):—"There are but very few localities in these 20,000 square miles where any noteworthy value has thus far been obtained from the formation in the line of these coveted supplies, and but a single field of large production"? A few more fields have been found in the Berea grit since the above was written, such as Corning, Scio and others, but yet, after very considerable drilling, not one per cent. of the 20,000 square miles has been found productive; and, where it has been, as remarked also by Orton in the same report, an "abnormal structure or dislocation of the strata" was noticed, like at Macksburg. This to us indicates the fracturing of the stata necessary for the impregnation of the Berea grit and other "sands" with oil and gas.

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(1) Ann. Rep. Pa. Geol. Surv., 1885, p. 665.

(2) Oil and Gas Region Report, P Geol. Surv. 1890, pp. 12 and 13.

(3) Bull. Geol. Soc. of Am., vol 9, pp. 95 and 96.

(4) Edward Orton, Geol. of Ohio, vol. vi., p. 311 *et seq.*

But where the localization of oil is most striking is in the famous oil field of the volcanic peninsula of Apscheron, near Bakou, Russia, where, from a small area of not over eight square miles, a production of oil of over 900 million barrels has now been obtained.

We may yet cite another instance of this local distribution of oil, and this is an interesting one for two reasons: first, because it is of oil in the shales, and it will prove that even shales are far from being bituminous all over, and second, because the explanation of why the shales are bituminous in one section and not in the other is here quite apparent and instructive. We refer to the oil-shale fields of the Lothians in Scotland. In his paper on these oil-shale fields, previously cited, Mr. Cadell (2) says:—" Although the Calciferous Sandstone series is well developed in other parts of Scotland it has not as yet yielded any oil-shale outside of this area. It is also a remarkable circumstance that the beds of the oil-shale group which are well developed along the western side of the Dalkeith basin, emerge in East Lothian on the opposite edge of the trough, quite barren as far as oil is concerned. In the same way, the shale-measures of West Lothian, which dip westward under the Stirlingshire coal-field and crop out again under the limestone some miles to the west without any oil-bearing shale, prove that during a long period in the Carboniferous age the necessary physical conditions for the disposition of oil-shale were confined within this limited area." We have here both the facts in regard to the localization of the oil in the shales and also Mr. Cadell's rather vague explanation of them, With this last we cannot agree as we do not see how the physical conditions in organic growth and decomposition (which, we take it, is Mr. Cadell's meaning) could be so different during a long period in districts so close one to the other. But, in looking at Mr. Cadell's map, we at once notice that the oil is found in the shales of the districts where the red spots or volcanic rocks are, while, where these are not represented, the shales are quite barren as in East Lothian, on the east side of Dalkeith basin. That, we have already submitted, is the explanation :—the hydrocarbons and other emanations accompanied the volcanic rocks which, as we have seen, contain in their intimate texture solid witnesses and proofs of it in the form of ozocerite.

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(1) *Ibid.*, p. 327.
(2) Trans. of the Inst. of Min. Eng., vol. XXII, pt. 3, pp. 316 and 318.

This very local and accidental distribution of the oil and gas fields is very unlike what would be expected from deposits of organic origin, which like the coal beds would naturally spread out uninterrupted over wide regions. On the other hand, volcanic products are "*a priori*" found localized along the lines of volcanic activity, and there in large quantities, while the neighboring localities, or districts, not subjected to this volcanic action are barren. If we now recall the well known geological fact that the volcanic activity is, and has been during all geological ages, shifting and intermittent along the fractured zones of the earth's crust, that is to say that while it manifested itself intermittently in a certain region during a certain period, in subsequent ages, it died out and became entirely quiescent in that particular region, to break out anew in other portions of the earth, then we will realize that natural gas and oil, though volcanic products, are to-day in most every field where they are found, stored products not now renewing themselves in the recesses of the earth. We will also thus understand why the rock pressure and quantity gradually decrease as we take these products out of their deposits:—the volcanic activity which brought them there, through faults and fissures, was active, as it always is, only for a time, and now that this activity has expired these faults and fissures have closed up and the volcanic force is unable to refill the reservoirs, just as it is in most mining regions of the earth, where, a similar volcanic energy was, at one time, the immediate cause of the filling of fissures, veins and lodes now long ago solidified with quartz and other vein-stones more or less mineralized.

(C.) Complete inadequacy of all organic theories of origin.

We have shown that volcanic emanations of hydrocarbons are a natural geological process of to-day, abundantly verified and witnessed in actual operation in volcanic eruptions and phenomena all over the world.

Can as much be said of any of the organic theories generally advanced to explain the origin of hydrocarbons? Evidently not! None of the processes called on by these organic theories are to be witnessed in operation anywhere in nature to-day. The late professor Edward Orton, a profound believer in, and a strong defender of the organic origin of petroleum, acknowledged this point plainly when he said in his presidential address before the Geological Society of America:—(1) "It is easy to see how the bituminous series may result from the destructive distillation of either vegetable or animal substances enclosed in the rocks, and wherever conditions can be shown that provide for such distillation we are not obliged to go further in our search. Destructive distillation can take effect in organic matter that has attained a permanent or stable condition in the rocks, like the carbonaceous matter of black shales or coal; but it seems improbable on many and obvious grounds that this can be the normal and orderly process of petroleum production. This production of petroleum must be in active operation in the world to-day; at least it seems highly improbable that a process coeval with the kingdoms of life, growing with their growth and strengthening with their strength, a process that was certainly in its highest activity throughout Tertiary time, bearing a most important record in the rocks of that age, should suddenly and completely disappear from the scene upon which it had wrought so long and upon which all other conditions appear to be substantially unchanged." We have seen above how far from having disappeared from the scene is the volcanic process of petroleum production; but Professor Orton was only looking to find in nature a petroleum production process "coeval with the kingdoms of life" and that he could not find simply because it does not, and never did exist. To us this is most clearly proven by the simple consideration of the natural geological processes of decomposition of organic remains and of the conditions pertaining in the oil and gas fields.

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(1) Bull. Geol. Soc. of Am., vol. 9, p. 90

First:—It is quite certain that the decomposition of animal bodies, as taking place in nature to-day and we may, no doubt, say during all ages, is so rapid that the decay or cumbustion is complete before the entombment in the sedimentary rocks of these animal bodies, preserved in any way, can possibly take place. This is no doubt why instances are so rarely cited in geology of partially decomposed and preserved remains of animal bodies being found; only most exceptional cases, such as a few remains preserved in the antiseptic waters of peat bogs, or a few frozen remains of Elephas, are given; but these exceptions only confirm the rule which is, viz, when there is anything left at all it is the shell, or bones, or their moulds, or casts, and no trace of the body is to be found. The fact that a few shells have sometimes been found full of petroleum is a conclusive proof that this oil is a subsequent infiltration into the shell as in the case of silt, silica, pyrites, calcite and many other minerals filling shells:—a modicum of oil is all each shell would contain if the petroleum originated from the body, and invariably, when petroleum is found in fossil shells, it is also found in the porous, or seamed strata, in which the shells are embedded showing the infiltration and impregnation from without.

Second:—It is also equally certain that there is only but one normal process of decomposition and preservation of vegetable organic matter in nature to-day, and in ages past, and that is the decomposition of it into carbonaceous matter, viz., peat, lignite and coal. This process is in active operation in the world to-day, as it has always been, and it is the only normal process "coeval with the kingdoms of life" that geology teaches us. Not one single authenic instance can be adduced, from the actual normal processes of nature, of any decomposition of organic matter "primarily" into petroleum. How could it be? The same conditions of low temperatures, and of all other factors, entering in the normal decomposition of vegetable remains must give only the one result, and cannot possibly give two different ones, especially in the same strata and, the same places, for oil sands and coal beds are often contiguous. If then we do not find carbonaceous matter in any quantity below the Carboniferous period, as the A.B.C. of geology teaches us that we do not, the simple reason of it is, as long ago admitted by geologists, that, before that period, the favorable conditions for vegetable growth had not yet developed to any extent, and not that it was transformed into petroleum as attested by the small quantity of carbonaceous matter found in the Devonian and Silurian strata, which are witness and proof that the one normal process of decomposition of vegetable matter into coal was then already going on.

Then, since animal organisms were never entombed in the rocks, and since vegetable life was quite insufficient before the Carboniferous Age, how can the organic theories of origin be adduced to explain all the oil and gas found below the Carboniferous?. That means all the enormous quantities of oil and gas of the Lower Silurian limestone of Ohio and Indiana, and it also means almost all of the very large quantities of oil and gas developed in the last 40 years ago along the Appalachian belt which has been found under the coal in the Lower and Sub-Carboniferous and in the Devonian and Silurian; and, much more in other fields. The fact often cited by the numerous exponents of the organic theories, as in the above quotation of the late Professor Edward Orton, that, by destructive distillation, petroleum and gas can be obtained from coal or carbonaceous matter, and also from fish oil, lard oil, or linseed oil, &c., (1) will not serve here at all, for not only there was too little to distill in the rocks prior to the Carboniferous, but what little there was, was not distilled and is to be found there to-day, undistilled, as the Paleozoic oil rocks of the oil regions of North America have without the shadow of a doubt, remained unaffected by metamorphic agencies and have never been subjected to the heat necessary to effect this distillation of organic matter. Nor have the rocks of the Texas section, and yet we have seen that petroleum, gas and asphalt are found in them from the Ordovician to the Quaternary. This destructive distillation of carbonaceous matter (and, we repeat, there is no other organic matter entombed in the sedimentary rocks but carbonaceous matter) could not possibly take place without leaving a residue of coke and of ash, and not only these residues have never been found under the oil and gas fields, but we know for certain that they do not exist.

In fact, if this distillation had taken place, there would be no coal fields anywhere as they would all have been changed into coke beds.

We see, therefore, to what absurd deductions we are led by the organic theories of origin of petroleum, viz: 1st. Abundance of vegetable life before the Carboniferous. 2nd. No coal anywhere on the globe.

No doubt the late Prof. Orton felt the force of the absurdity of the above first proposition when, after the discoveries of oil and gas in the Lower Silurian limestone of Ohio, he wrote in 1888 (2): "When required to believe that certain phases of this Trenton limestone make one of the great oil rocks of our geological scale, one which produces from single wells, 5,000 barrels of oil and 15 million cubic feet of inflammable gas in a day, it is hard to prevent our surprise from passing into incredulity." Yet ten years later the same able geologist said:—(3) "Geologists believe that petroleum is, in all instances, derived from organic matter."

This forcibly demonstrates the wonderfully enduring strength of

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(1) Prof. E. Orton, Bull. Geol. Soc. of Am., vol. 9. pp. 88-89.

(2) Geol. of Ohio, Vol. VI, p. 101.

(3) Bull. Geol. Soc. of Am., Vol. 9, p. 87.

"faith," but we humbly submit that Science wants more than "faith" and demands demonstration.

Mr. G. R. MICKLE, Toronto (*Contributed*).—Ever since reading the chapter on Carbon and the Hydrocarbons in Mendelejeff's "Principles of Chemistry" (Vol. 1, p. 326 and following, in Trans. from 5th Russian Edition by Kamennsky, pub. Longmans Green & Co.) I have never been able to believe in the organic origin of petroleum, natural gas, and even certain anthracitic minerals. Since Mendelejeff wrote, the constantly recurring discoveries of these hydrocarbon products in places where they have no business to be, have, I think borne out his theory and severely taxed the ingenuity of our organic friends to explain. The eruption of vast quantities of inflammable gas at Martinique described in Mr. Coste's paper seems to corroborate Mendelejeff's and Mr. Coste's theory entirely; what a grand well it would have made if one could have caught the gas and stored it up!

I cannot do better than quote Mendelejeff fully, as he mentions some points in favor of inorganic origin not brought out in Mr. Coste's paper. After discussing the composition and characteristics of petroleum, he says, p. 364, ob. cit. "Whether naptha (or petroleum) was formed from organic matter is very doubtful, as it is found in the most ancient Silurian strata which correspond with epochs of the earth's existence when there was little organic matter; it could not penetrate from higher to the lower strata more ancient) as it floats on water (and water permeates through all strata.) It therefore tends to rise to the surface of the earth, and it is always found in highlands parallel to the direction of the mountains. It is much more probable that its formation would be attributed to the action of water, penetrating through the crevices formed on the mountain slopes to the heart of the earth, on that kernel of heated metallic matter which must be accepted as existing in the interior of the earth. And as meteoric iron often contains carbon (like cast iron), so, accepting the existence of such carburetted iron at unattainable depths of the earth, it may be supposed that naptha was produced by the action of water penetrating through the crevices of the strata during the upheaval of mountain chains, because water with iron carbide ought to give iron oxide and hydrocarbons. Direct experiment proves that the so-called spiegeleisen (manganiferous iron, rich in chemically combined carbon) when treated with acids gives liquid hydrocarbons, which in composition, appearance, and properties are completely identical with naptha.

As during the process of the dry distillation of wood, seaweed and similar vegetable debris, and also when fats are decomposed by the action of heat (in closed vessels) hydrocarbons similar to naptha are formed, it was natural that this should have been turned to account to explain the formation of the latter. But the hypothesis of the formation of naptha from vegetable-inevitably assumes coal to be the chief element of decomposition, and naptha is met with in Pennsylvania and Canada, in the Silurian and Devonian strata, which do not contain coal, and correspond to an epoch not abounding in organic matter. If we ascribe the derivation of naptha to the decompotion of fat (adipose animal fat), we encounter three almost insurperable difficulties : (1) Animals remains would furnish a great deal of nitrogenous matter, whilst there is but very little in naptha; (2) the enormous amount of naptha already discovered as compared with the insignificant amount of fat in the animal carcase; (3) the sources of naptha always running parallel to mountain chains is completely inexplicable. Being struck with this last mentioned circumstance in Pennsylvania, and finding that the sources in the Caucasus surround the whole Caucasian range (Baku, Tiflis, Gouria, Kouban, etc.) I developed in 1876, the hypothesis of the mineral origin of naptha expounded further on.

During the upheaval of mountain ranges crevasses would be formed at the peaks with openings upwards, and at the foot of the mountains with openings downwards. These cracks in course of time fill up, but the younger the mountains (the Alleghany mountains are, without doubt, more recent: they were formed during the tertiary epoch) the fresher the cracks: through them the water must gain access deep into the recesses of the earth to an extent that cannot occur on the level. The situation of the naptha at the foot of mountain chains is the principal argument in my hypothesis.

Another fundamental reason is the consideration of the mean density of the earth. Cavendish, Airy, Cornu, and many other who investigated the subject by various methods, found that, taking water=l, the mean density of the earth is nearly 5.5. As at the surface water, and all rocks (sand, clay, limestone, granite, etc) have a density less than 3, it is evident (as solids are but slightly compressible even under the greatest pressure) that inside the earth there are substances of a greater density, namely, not less than 7 or 8. What conclusion can be arrived at? Something heavy contained in the bosom of the earth must be scattered not only on the surface, but in the whole solar system, because everything tends to show that the sun and planets proceed from the same material, and, according to the hypothesis of Laplace and Kant, it is most probable, and even ought to be held, that the earth and planets are but fragments of the solar atmosphere which have had time to cool considerably and become masses semi-liquid inside and solid outside, forming planets and satellites. The sun, amongst other heavy elements, contains a great deal of iron, as shown by the spectrum analysis. There is also much of it in an oxidized condition on the surface of the earth. Meteoric stones, carried as fragments of the planets in the solar system and sometimes falling upon the earth, consisting of siliceous rocks similar to terrestrial ones often contain dense masses of iron . . . . For this reason it is possible that the interior of the earth contains much iron in a metallic state. This might be expected from the hypothesis of Laplace, for the iron must have been compressed into a liquid at that period when the other components of the earth were still strongly heated, and oxides of iron could not yet be formed. The iron was covered with slags (mixtures of silicates, like glass fused together with rocky matter) which did not allow it to burn at the expense of the oxygen of the atmosphere and water, just at that time when the temperature of the earth was very high. Carbon was in the same state; its oxides were also incapable of dissociation (Deville); it is also but slightly volatile, has an affinity for iron, and iron carbide is found in meteoric stones. On this account the supposition of the existence of iron carbides in the interior of the earth was drawn by me from many indications, some of which are confirmed by the fact that granular pieces of iron have been found in some basalts (ancient lavas) as well as in meteoric stones.

The following is the typical equation for this formation:

$$3\ Fe_m\ C_n + 4_m\ H_2O = m\ Fe_3\ O_4 + C_{5n}\ H_{8m}$$

Cloez investigated the hydrocarbons formed when cast iron is dissolved in hydrochloric acid, and found $Cn\ H_{2n}$ and others. I treated crystalline manganiferous cast iron with the same acid, and obtained a liquid mixture of hydrocarbons exactly similar to natural naptha in taste, smell, and reaction. The occurrence of iron with carbon during the formation of the earth is all the more probable because those elements predominate in nature which have small atomic weights, and among them the most widely diffused, the most difficultly fusible, and therefore the most easily condensed are carbon and iron. They passed into the liquid state when all compounds were at a temperature of dissociation."

Mendelejeff further shows how gases and petroleum might be retained in suitable rocks.

Mr. Coste, I understand has followed out his theory in boring for gas, and his efforts have been successful, it is very seldom that anyone is able to carry out of any controversy such substantial trophies as some of the best gas wells of Ontario—and leave his opponents nothing but a badly punctured theory. I can only admire his courage and congratulate him on his success.

Dr. ROBERT BELL: Ottawa *(Contributed)*.—Mr. Coste has given us many interesting details showing the occurrence of petroleum and natural gas in connection with volcanic phenomena, but he has not proved to a demonstration that either of them is formed without the presence of organic matter or of substances derived therefrom. Many years ago, it was asserted by some, but without any scientific basis, that petroleum may have been formed from inorganic compounds by the breaking up of their molecules with the liberation of carbon and hydrogen, which then united with each other. Thus, it was supposed that the hydrogen of water might unite with the carbon or carbon dioxide; that is to say that two very stable compounds might break up and form a less stable one.

Petroleum is generally believed by chemists and geologists to have been derived entirely from organic matter, more especially of vegetable origin. The soft parts of animal remains would, in nearly all cases, decay and vanish before the hard parts (which are all that remain as fossils) had been embedded in the sediments.

Petroleum is sometimes found in unaltered strata, in which it appears to originate, although such beds contain few, if any, visible organic remains. In such cases the vegetable matter has probably existed in the form of small particles, diffused through the rock, which have been derived from minute plants that lived at the time it was being deposited.

When the occurrence of petroleum is associated with volcanic phenomena the latter have acted only in a secondary way by the possible conversion into oil of the bitumen or fossil vegetable matter present in sedimentary strata within reach of the volcanic influence.

If Mr. Coste could prove the exact chemical process by which molecules of petroleum or of hydrocarbon gas can be found by any kind of volcanic action and could illustrate the process by examples in nature,such demonstration would show one way in which petroleum could originate. But he has not given us any proofs of this kind, and therefore his theory will fail to satisfy the scientific mind. Even if it could be shown to be possible that petroleum might originate in some such way as Mr. Coste imagines, the fact would remain that it is reasonably certain that the great bulk of the petroleum with which we have become acquainted has had its origin in the plant life of past ages.

Mr. Coste has, however, given us a very interesting paper and has made the most of such facts as appear to support his arguments. One of the most striking of these is the occurrence of a very little tarry matter in a greenstone dyke at Tar Point in Gaspé. I have examined this dyke and observed that the tar occurs, not in the body of the dyke, but only on one of its walls, in the form of a few small and widely separated irregular vesicles, each associated with a fragment of bituminous limestone, partly converted into calcspar. Although the dyke is here actually in sandstone the latter is underlaid by a great thickness of petroleum—bearing limestone, through which the dyke must have cut before reaching the sandstone, and, no doubt, the fragments of limestone containing the tar were caught up or entangled in the outer part of the viscid magma as it pushed its way upward into the sandstone, where it solidified.

While Mr. Coste has made an able presentation of whatever may be said in favour of his contention, he has not referred to the many facts which are arrayed on the other side of the argument and which, if impartially interpreted, leave little room to doubt the organic origin of petroleum. Still his highly interesting paper is a valuable contribution, setting forth what may be said in opposition to the generally received views on this subject.

Mine Timbering by the Square Set System at Rossland, B.C.

By BERNARD MACDONALD, M.E., Rossland.

In mining operations, when the ore extracted exceeds a width of 12 or 15 feet, it has been found that the cheapest and only effective method of timbering is by the square set system.

The system may be generrally described as a rectangular skeleton framework of timbers, extending from wall to wall of the vein as exhausted, the different members of which are so framed as to stiffen and support each other, and equalize and distribute local strains after the manner of a truss.

HISTORICAL.

The square set system of timbering was invented by Philip Deidesheimer, while Superintendent of the Ophir Mine, on the Comstock Lode, in 1860.

In Monograph IV. of the United States Geological Survey "Comstock Mining and Miners" the following reference is made, which will be found interesting under this heading:

"At the fifty foot level (of the Ophir Mine) the vein of black sulphurets was only three or four feet thick, and could readily be extracted through a drift along its line. propping up the walls and roof, when necessary, by simple uprights and caps. As the ledge descended, the sulphuret vein grew broader, until at a depth of 175 feet it was 65 feet in width, and the miners were at a loss how to proceed, for the ore was so soft and crumbling that pillars could not be left to support the roof. They spliced timber together to hold up the caving ground, but these jointed props were too weak and illy supported to stand the pressure upon them, and were constantly broken and thrown out of place. The dilemma was a curious one. Surrounded by riches, they were unable to carry them off.

"The company was at a loss what to do, but finally secured the services of Philip Deidesheimer, or Georgetown, California, who visited and inspected the treasure lined stopes of the Ophir."

During Mr. Deidesheimer's engagement at the Orphir, all the principles of square set timbering were evolved under his immediate supervision, and the wide and rich ore bodies occurring in that mine were successfully extracted without the loss of ore or injury from caving by the use of this system. The system was then used in all the mines on the Comstock Lode, and subsequently, in all metalliferous mines elsewhere where the ore bodies exceed a width of 15 feet, the extreme width that is practical to timber by stulling.

The "square set" has underwent numerous modifications of detail in dimensions and the framing of its members in the various camps where it has been since used, owing mainly to local conditions, the dip of the vein and the character of the ore bodies and the enclosing rock.

VEIN CHARACTERISTICS AT ROSSLAND.

In the Rossland mines, the ore deposits have widths ranging up to 100 feet or more, and lengths of several hundred feet along the veins. The veins are sheer zone fissures, the vein-filling consisting of shattered country rock, which is now found, replaced, and cemented to various degrees of completeness by auriferous pyrrhotite and chalcopyrite.

The ore and the enclosing rock may be designated as extremely hard, and the veins dip at angles of about 70°. These conditions facilitate and simplify timbering, without, however, doing away with its necessity.

PRELIMINARY WORK.

In stoping out these deposits, the work is begun at the level drives or drifts run in the vein, and continued upwards in steps or stopes.

The first work in opening up an ore shoot or deposit preparatory to extraction, consists of running drives out through it from the level stations at the shaft, which are generally cut at distances of from 100 to 200 feet in depth below each other. Such drives may happen to be run along either wall of the vein, or, through the vein at any point or distance (usually varying) from either wall.

These drives are considered as random bores, made longitudinally through the vein to determine, in a general way, its course or strike, and the behavior and characteristics of the ore shoot. They serve, besides, as preliminary thoroughfares for the traffic, drainage, and ventilation necessary for the work preparatory to stoping, to be hereafter described.

As generally run, the drives have widths of about six feet, and heights of about eight feet, and require no timbering, owing to their comparatively small size and the hardness of the vein rock.

When it is decided to begin stoping on any new level, the first work done is to excavate the ore along the drives from wall to wall of the vein, making the excavation of sufficient height to receive the "sill floor set" of timbers, as the first series of square sets on the level is called, and to leave a space of two or three feet over the set. This space serves to provide room for blocking and wedging the timbers to place and to receive a layer of old timbers or broken ore to act as a cushion in preventing the possible breaking of the timbers by the masses of rock that must be blasted down on them, as the work of stoping out the ore above proceeds.

SILL FLOOR CONSTRUCTION.

The sill floor is a framework, made of 10 in. x 10 in. sawn timbers, laid down on the working level in the ore body which serves as the sills or foundation timbers on which the square sets are to be erected. It is, therefore, the first, as well as the most important part of the square set system of timbering.

Fig. I, in the plate shows the sill floor as laid down and ready to receive the "sill floor set" of timbers. The members of the sill floor consist of three pieces: the stringer, or long sill; the spreader, or short sill; and the butt spreader, or brace. These members, when repeatedly laid in duplicate, will make up a sill floor to any extent required by the size of the deposit.

The dimensions and details of the framing of these members are also shown on the plate.

The long sill measures 15 feet over all, and is framed from a 16 foot timber, which allows six inches to be cut from either end to square the piece of and remove sun-cracks.

The short sill, as framed, measures 5 feet 4 inches in length, over all, three of which may be cut from a 16 foot timber, if it overmeasures a few inches, as it generally does, and the ends are sound.

The butt sill or brace is framed of varying lengths to suit the existing space, which generally varies owing to local bulgings or contractions of the vein. It is framed on one end exactly like the short sill, while the other is cut square or bevelled to fit or butt against the wall rock, from which it is wedged tightly to place against the long sills.

A description of the method of framing the sill floor set of timbers is not needed, as the method will be fully comprehended by a glance at the figures on the plate.

In laying the sill floor the long sills are set ends abutting flush against each other, and as nearly as possible parallel with the general strike on the vein, ignoring any bulging of the walls.

The first sill is laid close and approximately parallel to the foot wall, in which position it is levelled and held by blocking or butt braces; the other long sills are laid paralleling this one at proper distances apart, that is, 5 ft. 4,in. between centres. The cross sills fit on top of these, lying level with them, the ends being halved in framing to rest into similar halvings in the long sills, and to abutt flush against each other and extend endwise from wall to wall of the vein.

When the long sills reach as near the hanging wall of the vein as desirable, they are braced from it by the butt spreaders or by blocking, wedged tightly to bring all the members into proper position. The philosophy of this design of the sill floor is as follows:—

The long sill is made 15 feet in length, so as to better sustain the superstructure of square sets erected on it when the ore upon which it rest comes to be stoped away. For instance, when the ore is being blasted from under the sill floor by the work of stoping coming from the level below, and the blasting tears away a portion of the ore upon which the sill floor rests, making an opening as it generally does, of, say, 8 x 8 feet, the long sills would overreach such opening, and one or both ends would rest on the solid rock beyond, Nor would the short sills drop away through such opening, owing to the fact that they rest on the top of the long sills, as previously described and shown on the plate.

Through the opening thus made in the ore, the portion of the sill floor exposed would be supported by posts set on the timber sets in the stope below. Thus the long sill operates to allow the work of stoping out the ore upon which the sill floor rests to be safely conducted if such portions of the sill floor as become exposed as the work proceeds are properly supported by posts from the timber sets underneath.

TIMBERS AND METHODS USED AFTER SILL FLOOR IS LAID.

The first tier of square sets erected on the sill floor is known as the "sill floor sets." The assemblage of the framed timbers into square sets then prooceeds upwards, by floors, set over set, vertically, *pari passu* as the work of stoping exhausts the vein. The timber structure over any level is referred to in subdivisions as the "sill floor sets," "first floor sets," "second floor sets," and so on until it reaches the next level above and catches up and supports the sill floor on that level.

This method of reference to the timbering as it advances, carries with it the data for a general calculation of the portion of the vein exhausted over a level as each set of timbers in place indicates that 9 feet vertically and 5.3 feet horizontally of the vein is exhausted, 9 feet being the bare height and 5.3 feet the width of space required for a set of timbers. And each square set in place indicates that 24 tons of vein matter have been extracted.

Aside from the sill floor, all the timbers employed in the square set system, except the planks for floorings and chutes, are framed from round logs. These logs are preferably of red fir, it being the strongest native timber, but pine, spruce and tamarac may be used. When cut in the woods, the logs are peeled and allowed to season for a period of from six to twelve months, during which time they lose about one-third of their green weight, which is a very important advantage in subsequent handling. In diameter, they range from 12 to 20 inches, but generally average about 16 inches, and are sawn in lengths of 16 feet 6 inches.

The logs may be framed by hand or with machine saws into the various members of the square set, as follows, viz: Posts, caps, girts or braces, and butt caps. Like the members of the sill floor, these members may be duplicated to any extent required by the size of the excavation to be timbered.

The posts as framed are 8 feet 2 inches over all; the caps are 5 feet 4 inches, and the girts or braces are 5 feet; the butt caps, like the butt spreaders on the sill floor, are cut in varying lengths to suit such spaces as may exist.

The details of framing the logs into members of the square set are plainly shown in on the plate, and need no further description. The philosophy of this method of framing the timbers is that the cap pieces of the various sets form continuous stringers of timbers running horizontally from wall to wall of the vein, no matter what this distance may be. Such stringers offer the end grain or greateat strength of the timbers to the walls, from which the greatest strains are generated. The post and girts rigidly support the stringers thus formed of the several cap pieces in true horizontal position, bearing on the joints from right angled directions, while the cap pieces and the girts support the posts in true vertical position.

The whole framework forms a strong rigid structure capable of indefinite extension upwards and longitudinally as stoping proceeds, allowing at the same time for any expansion and contraction in width to suit such irregular widths of the vein as may occur.

Besides the functions of the various members of the square set system to support each other in the manner described, that of the cap pieces is to receive directly and sustain the strains coming from the walls of the exhausted deposit, while that of the posts is to support the vertical weight coming from the undercut ore deposit and the broken ore lying on the floors, but strains coming from any direction are distributed over all the members of the set.

The system possesses, to a considerable degree, the qualities of a truss, and makes it possible to extract all of the ore of any deposit and effectually secure the enclosing walls from caving in. When the framework comprising the sets is erected, a floor, consisting of 3-inch plank, is spiked down on the caps of each floor set. These are the working floors on which the miners operate the machine drills, in the method shown in Fig. 5. When the ore is dislodged from the vein by blasting, it falls on these floors, where the waste or second class ore may be sorted out from the shipping ore. The shipping ore is shovelled into chutes which are built of 4-inch plank spiked to the timber framework and carried upwards with the square sets, as shown in the plate. The second class ore or waste sorted out, may be stored temporarily or permanently in the framework of the timbering from whence it may be drawn off at any time through chutes, should removal elsewhere be desired.

Figs. 4 and 5 are ideal cross and longitudinal sections illustrating the method of timbering and the work of stoping as it is carried on between the levels. Fig. 4 is a cross-section through the line A-B on Fig. 5, which in turn represents the longitudinal section through the line C-D on Fig. 4. On Fig. 4, the original position of the level drive in the vein is assumed as shown at the point X, This drive, as already stated, furnishes the point from which the excavation of the vein matter for the sill floor is commenced.

The step method of excavating the ore is shown in Fig. 5, where stoping is proceeding in double-headed steps, each step excavating the ore from wall to wall and having a vertical height of 9 feet in the clear, which allows of the direction of one floor of timber sets, which in turn provides the scaffolding from which the miners may attack the ore above.

In stoping out the ore on any level, the ordinary method is to keep the sill floor at least 30 feet in advance of the first floor, and it about 30 feet in advance of the second, and so on, as is shown in Fig. 5. One machine-drill, or generally two, in case the vein is wide, are assigned to work the two opposise headings of any floor, going in opposite directions, working on each heading alternately. When one face is drilled and blasted, the machine-drills are changed to the opposite face, and the shovellers pass the broken rock into the chutes, or sort it, if sorting is required. When the ore broken is thus removed from the face the timber gang erects another unit of the square sets there, and the stope is again in readiness for the machine drills, which have by this time finished drilling on the opposite face.

Generally the step method of stoping proceeds in opposite directions from a raise, run through the ore body between the levels, as shown in Fig. 4. The framed timbers are delivered in the stope by dropping them down through this raise or hoisting them from the level. Sometimes the framed ends of the timbers are injured by dropping them through the raise, but as a rule no material injury is done to them, while the time gained by this method is a very important factor in cheapening the cost of timbering, compared with hoisting piece by piece from the sill floors underneath.

PER TONNAGE COST OF SQUARE SET TIMBERING

After the sill floor is laid and the framework started, a square set, which is made up of one post, one cap and the brace, consumes 18 feet 6 inches running measurement of logs.

The logs peeled and seasoned cut measuring 16 feet 6 inches cost $1.20 each delivered f.o.b. the cars at the works, or about 8 cents per running foot. Therefore, the 18 feet 6 inches required for the set would cost $1.48, or say $1.50 unloaded in the framing shed, provided the logs are not cut to waste in framing, which may be avoided with a little care and foresight.

The cost of framing the pieces comprising the set would be about $0.553, when framed by hand labor, carpenters being paid $3.50 per day of nine hours.

COST DATA PER SQUARE SET, HAND FRAMED.

Material.—A log, measuring 16 ft. 6 in., costing $1.20, cuts into two posts, or three caps, or three braces; therefore:

Material in one post costs	$0 65.0	
" " cap "	0 43.0	
" " brace "	0 43.0	
Total cost of material in one set is say....		$1.50.0

Labor.—One carpenter (wages $3.50) frames per day:

About 21 posts, costing each	$0 16.7	
About 21 braces, "	0 16.7	
About 16 caps, "	0 21.9	
Total cost for framing		$0.55.3
Total cost of labor and material in set		2.05.3

The details of cost of the individual members of the set framed on the surface, ready to go into the mine are therefore as follows:—

1 post costs, for.	Material..	$0 65.0	$0 81.7
	Labor	0 16.7	
1 cap costs, for..	Material..	0 43.0	$0 64.9
	Labor	0 21.9	
1 brace costs, for.	Material..	0 42.0	$0 58.7
	Labor	0 16.7	
Making the total cost			$2.05.3

Fig. 5.

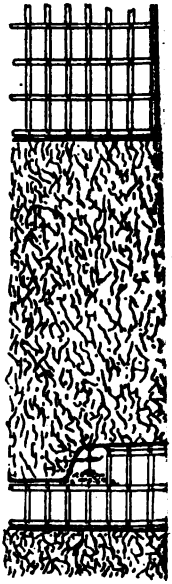
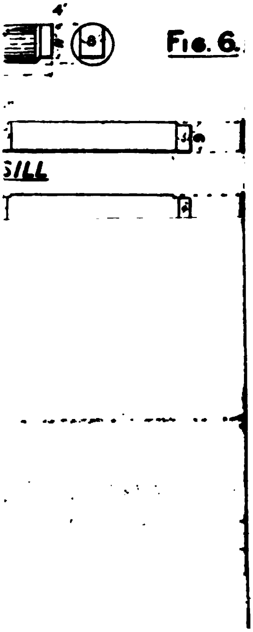


Fig. 6.



The costs next attaching to the square set, or unit, on this method of timbering are :

Lowering into the mine...........	approximately	$0 10	
Delivering to place required........	"	0 10	
Labor in erecting..................	"	1 50	
Incidental material, such as blocks wedges, tools, nails..........	"	0 10	
Cost of sill floor averaged over 11 sets between levels 100 ft. apart.	"	0 15	
Cr. to total of......................			$1 95

These costs last above given may vary greatly, being increased or decreased with the completeness of the facilities for handling the framed timbers, the cost of the several items as stated may vary accordingly from time to time, but the total will be about the average cost, which will closely approximate that of carefully supervised operations. Therefore, from the foregoing, it will be seen that the cost of the square set placed in the mine will come down, as follows :

Total Cost of Labor and Material, as above	$2 05.3
Labor and material when set is in place as above.....	1 95.0
Total cost say..............................	$4 00.0

When framed by machine saws, the cost of framing a square set does not exceed 30 cents, including the cost of power, as against 55 cents by hand, a difference of 25c. per set. Therefore, if the framing is done by machinery, the cost of a set in place would be $3.75 as against $4.00 as shown above when the framing is done by hand work.

The per tonnage cost for timbering by this method works out as follows :—The average space to be excavated for each set square is 5.3 feet wide by 5 feet long, by 9 feet in height, or 240 cubic feet. The Rossland, ores, being heavily impregnated with iron and copper pyrites, yield a ton of 2000 pounds for each 10 cubic feet of ore in place ; therefore, from the 240 cubic feet of vein required to be excavated for a set of timbers, the yield will be 24 tons. If the timbers were framed by hand the cost of timbering, so far as described, would be about $0.17 per ton ; by machinery, $0.15.6, a difference of $0.01.4 per ton in favor of the machine-framed sets.

In addition to the costs above tabulated, there still remain the costs of the chutes, floors, ladders, and railings, necessary for the convenience and safety of the miners and the passage of ore and supplies. These require, on an average, about 100 feet of lumber, board measure, per square set, which, at $11.00 per 1000 feet, would add for the lumber $1.10, and for placing it, say $0.10, or a total of $1.20 to each square set, which would then cost, in the case of hand framing, $5.20, or a total cost of $0.21.6 per ton of crude ore; and in the case of machine-framing, $4.95, or a total cost of $0.20.6 per ton of crude ore.

INCIDENTAL COSTS.

The cost of timbering, per ton of ore shipped, would be greater than the figures given above in proportion to the quantity of waste or second-class ore that would be sorted out from the crude ore extracted.

In the Rossland mines about 20 per cent of the ore mined is sorted out and goes to the second-class ore dump to await profitable treatment, expected to come in the future. Deducting 20 per cent. of the twenty-four tons of crude ore in a square set, there would remain 19.20 tons as the shipping ore, against which the total costs of the square set as above, $5.20 or $4.95 as the case might be, would have to be charged. This would raise the per tonnage costs on the ore shipped to about $0.27 and $0.26 respectively.

Where there is a reasonable expectation that the second-class ore will eventually pay a profit after suitable treatment, it would be only fair to charge a *pro rata* cost of the timbering to it, and the cost would then remain $0.20.6 and $0.21.6 per ton as above.

In cases where, on account of bad ground, angle bracing, bulkheading, or cribbing and filling would be required, the per tonnage cost would be still further increased, but to a comparatively small extent.

LIMITATIONS OF THE SQUARE SET.

The limit of the capacity of the square set system as already described without any reinforcing devices to withstand the pressure that may be exerted on it by the enclosing walls of an ore-body when that ore body is extracted, may be reached.

This limit depends on the nature of the walls enclosing the deposit, and the extent of the excavation. If the wall rocks are solid and do not swell on exposure to the air and dip at a high angle, the ore body may be extracted between levels, say, 100 feet apart and for a length of 200 or 300 feet along the vein, and the pressure likely to be exerted by the walls will be sustained by the skeleton square sets without reinforcement of any kind.

If, however, the vein dips at a low angle, and the wall rocks are decomposed, or of a talcose or serpentine character and disposed to swell, the pressure that might be exerted on the timbers, when even a comparatively small excavation of the ore body has been made, may cause them to crush, "jack knife," or collapse, allowing the wall rocks to cave in and to close up the stope. When the members of the square set become squeezed out of the truly right-angled position which they should occupy, their capacity to resist wall pressure or strains from any direction is practically *nil.*

When, owing to wall pressure or imperfect erection of the sets, "jack knifing" of the square sets results, the cave-in, which sooner or latter may follow, with disastrous consequences, can be prevented by either bulk-heading, cribbing, or filling the skeleton framework of the timbers with rock.

The cost of the foregoing methods of reinforcement, which are the only practical ones that can be successfully used in bad ground, cannot be given with any general degree of accuracy, as that is so much affected by the local conditions in each case.

A general idea of what the cost is likely to be may be gleaned from the description following :—

REINFORCEMENT METHODS.

Angle-bracing.—If, after the square sets are properly erected in place, the members nanifest an inclination to swing out of the right-angled positions they originally occupied to each other, this tendency may be arrested and prevented by a system of angle-bracing. This consists of placing diagonal braces made of round or square timber on the sill floor and against the foot of the posts, and leaning the heads so they will fit snugly against the top of the posts underneath the caps or girts, as the case may be, and the next adjacent set. The head of this diagonal brace should lean in the direction from which the pressure comes, This method is illustrated in Figure 8.

Cribbing.—When the square sets manifest a stronger tendency to swing than in the case referred to, the collapse threatened may be prevented by crib-work. This consists of crossing alternate layers of round or square timbers of any convenient size between the posts ot the sets until the space between the sill and cap is filled, as shown in Fig 9. This crib-work may extend from wall to wall through two or more rows of sets if required, and the spaces between the sets thus cribbed may be filled with waste rock, but this is called " Filling," and will be referred to under that heading below.

Bulkheading.—This method of reinforcement consists of placing timbers closely together in much the same way as the crib-work above referred to, and wedging them tightly between cap and sill.

Filling.—This method consists of filling the spaces between the members of the square set with any material such as waste rock, earth, or sand. When the filling is done it is retained within proper bounds, and the necessary passageways are kept open through the timbers by building crib-work around them as described.

Waste rock for filling purposes is generally secured from the development or deadwork that is being prosecuted in other sections of the mine, but where a large quantity is required, it is often found necessary to mine it specially for that purpose, or draw it from the waste dumps on the surface. About eight cubic yards of material is required to fill the vacant space of the frame of a square set, and the cost of such filling will be the cost of obtaining and placing such material, together with the crib work required to retain it within proper bounds.

GENERAL REMARKS.

The square set system of timbering is used successfully and exclusively in all mines where large paying deposits of metalliferous ores occur.

Where favorable conditions, such as railway transportation and a moderate supply of timber exist, it is comparatively cheap, If care is taken in the construction of this system in the mine, it ensures that all the ore existing may be extracted without injury to the workman or the mine. Round logs or sawn timbers of any dimension, ranging from eight inches upwards, may be used, but the sizes are governed by the economic conditions and mining requirements.

In the mines of Rossland, the round logs or timbers used for the square sets cost $1.20 for each log 16.5 feet in length f.o.b. the framing shed at the mine. These logs are cut in the State of Washington, and delivered over the Spokane Falls & Northern railway on flat cars, over distances ranging from 45 to 75 miles, each flat car being loaded on an average with 60 logs. The unloading at the framing shed is done in a few minutes by cutting off the retaining standards on the flat cars, and allowing the logs to roll off on the storage platform.

Of course, where wagon transportation is required from the railway terminus, the expense will be correspondingly increased.

In every mining camp there will be more or less variation in the method of framing, and in the cost of the square sets in place, also in the tonnage of ore to be extracted from the space occupied by each square set.

Where the dip of the vein is at a flat angle or the walls are bad, shorter posts than those described herein will probably be more advantageous; the more vertical the dip of the ore deposit, the longer the posts may be and *vice versa.*

Where sawn lumber is comparatively cheap, three-inch plank is preferable to lagging poles for floors, on account of the better floor it offers for shovelling, and the fact that it may be removed and re-used.

(DISCUSSION)

Mr. ERNEST WOAKES, Nelson—I have read with much interest Mr. Bernard MacDonald's paper on the square set system of timbering used at the Le Roi mine and I should like to hear from that gentleman how he would have adapted his system to the peculiar conditions which existed at the Darien Gold Mines in the Republic of Columbia, South America, a mine of which the writer had charge some years ago.

In Vol. XXIX of the Transactions of the American Institute of Mining Engineers the above mine is fully described. The ore body may be roughly described as having the form of an irregular quadrilateral measuring 90 feet wide from north to south, and 120 feet long from east to west, and standing nearly perpendicular. The country rock was a decomposed andesite having many cleavage planes so that it was very liable to break up and cave if left unsupported The ore body was composed of boulders and rock fragments from the adjoining country rock varying in size from pieces as small as a walnut to masses of many tons weight. These fragments are generally completely angular partaking of a breccia-like formation but at times they were rounded and resembled a conglomerate. The rock fragments are completely surrounded and cemented together by concentric shells of crystalline sulphurets and calcite with a little quartz. The gold was mostly free and was found almost entirely in the cementing materials. The ore was very high grade.

Timber was fairly plentiful but as in most tropical countries the majority of it was of very poor quality. It commences to decompose almost as soon as cut and for all underground purposes cannot be relied upon for much over twelve months. The square set system was introduced and practical men from Nevada were engaged to teach the natives how to prepare and set up the sets. Round timbers were used for the posts and nothing under 18 inches diameter was put in. The caps were flattened by adzing on two sides and the ties were of sawn lumber 8 x 10 inches. Great care was taken in setting the sills in each level, they were set north and south, east and west, with the idea of making sure that the uppermost tiers in one stope would eventually correspond as nearly as possible with the sill sets of the stope above It was also found useful at times in the mine to know the exact bearing by means of the timbers. Very soon after starting stoping it was found to be necessary to keep the sets close up to the stoping faces or falls would occur. The conditions were much aggravated in the upper levels by the presence of old workings. Finally, after the whole width of the ore body had been stoped and the sets carried up from four to six sets high, it was found that the ore body was commencing to settle and the whole weight was on the timbers. Falls and caves became more frequent and finally a cave started above the upper floor and kept breaking away upwards to such an extent that it could not be cauhgt up and eventually the whole stope crushed in, the timbers being forced out of plumb as the weight on them increased. False sets and diagonal braces were put in to resist the pressure but this was of only temporary assistance. After the cave a tunnel was driven in the country rock round three sides of the ore deposit and crosscuts driven in from it and the ore extracted as it ran down, temporary sets being put in where necessary, in this way the ore was taken out until surface rock and tree stumps began to show in the stopes. In the deeper levels it was decided to try a different system. The square sets were put in as before but were only carried three or four sets wide all round the ore deposit leaving a large square pillar in the centre which was taken out as far as possible after the greater part of the ore body had been removed. Crosscuts were driven into the country rock from the various floors and the waste rock from these dumped into the stopes where the timber showed the worst signs of squeezing. It was not deemed prudent to leave any ore in the stope as filling it being of such high grade that the loss would be very great. Besides, as is unfortunately so often the case, the mill was generally calling on the mine for ore. It was a very wet mine and the rainfall was excessive, viz. : 110 inches a year. For this reason it was not desirable to have large open workings at the surface liable to sudden flooding, as would have been the case if filling from the surface had been resorted to as in the case with the Ymir mine in this country. I, of course, believe that in most cases where wide deposits have to be worked the square set system of timbering is the most satisfactory, if the mine can stand the cost of it, and after the mines have attained a certain depth it will often be found to be the only one possible. Luckily for mine managers conditions such as above described are not likely to exist very often, and if they do exist in the upper levels, it is to be expected that the ground will get harder and less liable to cave as depth is attained.

Mr. BERNARD MACDONALD, Rossland—I have read Mr. Woakes' criticism on my paper, "Mine Timbering by the Square Set System" and also that gentlemen's excellent article in Vol. XXIX of the Transactions of the American Institute of Mining Engineers, describing the Darien Mine, with great interest. I am sure any one who gives himself the pleasure of reading Mr. Woakes' description of this mining property will find corroborative evidence of the proposition that "no two mines are exactly alike."

In replying to Mr. Woakes' criticism I do so with the full knowledge of the difficulty of prescribing for a patient, withont first seeing him and studying the idiosyncrasies of the malady. Therefore, the method of stoping and timbering the ore bodies in the Darien Mine, which I would propose as best suited for the peculiar conditions existing there would be considered as given under existing circumstances.

As a general rule when an underground ore body is being mined, greater strains are exerted on the timbers by the pressure on the enclosing walls than from the overhanging ore. On this account, the method of extracting the ore body generally adopted is by stopes or steps running horizontally within the vein and along it over the various levels and the spaces thus exhausted are timbered by "floors" or square sets extending horizontally between the enclosing walls. This is the method described in my paper.

But it seems that the generally prevailing conditions in mining operations were quite reversed at the Darien Mine, where the greater strains came from the overhanging ore, instead of, as is usual, from the enclosing walls. This might, in a measure, have been suspected from Mr. Woakes' description of the physical characteristics of the ore and the nearly vertical dips of the enclosing walls.

I would meet these reversed conditions by reversing the usual methods, or I should say direction of the stoping and timbering, viz: I would run the stopes or steps of the excavation vertically upward between the mine levels, instead of horizontally over them.

For example: in stoping out any block of ore developed between two levels, I would first run a raise vertically through it, making such raise wide enough to be timbered into two compartments by two square sets going up in it side by side, When completed, this raise would furnish means of ventilation and access for men and material to whatever part of the ore body the work of stoping might be going on. I would then run all the stopes vertically upwards around this raise, commencing at the lower level and finishing at the upper level, mining out just enough ore at a time to admit of one new set of timbers being placed in the excavation. By this method all the ore, except the one stope being excavated, would be supported on a solid foundation of ore in place. In case lateral or vertical pressure would give the timber sets a tendency to swing or "jack knife" out of their true horizontal and vertical position, as would probably be the case, I would keep the skeleton frame work of the sets filled up with broken ore, until all the block between levels was broken down. This method of temporary filling locks up for the time being about two thirds of the ore in the stopes. The swell in volume of the broken ore over that in place being only about one-third. However, the two-thirds used for temporary filling could be drawn off after the work of stoping was completed, so that except for the time being no more ore used in filling would be lost.

This method would, in my opinion, be best calculated to meet the conditions existing at the Darien Mine.

Development of Coarse Concentration in the Slocan District, B.C.

By SAMUEL S. FOWLER, S.B., E.M., Nelson, B.C.

The silver-lead mining industry of the Slocan has now been alive approximately ten years, a time sufficient for it to have taken on a definite form and to have become of definite importance. This form, although, we think, not yet a perfected one, quite naturally has been attained only by passing through many struggles with nature and with man, and yet these both have done much toward its growth and its perfection. To-day it is just about holding its own in an equal contest; but it needs help to win and to survive.

It is not our purpose to discuss the form or extent of assistance necessary, nor yet to enter into many purely technical details of concentration as now followed: it is rather to consider what has been done towards working the deposits economically and thus doing all that is possible locally to bring about the stability of the industry.

Without considering certain evidences of an earlier knowledge of one or two deposits of ore, the "Slocan" first become known in the Autumn of 1891. The grade of the ores in silver was found to be so high that, although the price then was considered low (above 90 cents per oz.), the discoveries caused much excitement and the district was the scene of great activity during the year 1892. The activity was well justified, too, for during the year several shipments of ore were made, and these proved that, generally, wherever galena was found, it was of sufficiently good grade in silver to be marketed profitably containing as it did, say, 150 ounces or more of silver per ton, and 50 per cent. lead.

As is often the case, the region was a wilderness and "transportation" was far away. Kalso, on the west shore of Kootenay Lake, was the first town to be created because of the discoveries, and it was not long before the energy of its citizens took form in the building of a wagon road up Kalso Creek, 20 miles to Bear Lake. Many trails also were reaching out to many claims, and shipments were made on a sufficient scale during 1892 to afford a good knowledge of the resources of the region.

But, discouragement was soon to come, as it did in 1893, in the fall of silver. This, however, was only a shock which served to quicken the senses of the workers in this still new field, and with energy and a realization that expensive mining plant was not an essential, the claim owners kept on with such success in their efforts, that the Canadian Pacific Railway Company had a branch line well under construction during the year for the purpose of entering the field. This was completed in the autumn of 1894 as far as Three Forks, 36.6 miles from Nakusp on the Arrow Lakes. The year 1894 also saw the formation of a company to build a narrow gauge line from Kalso to Sandon, 28 miles, and this railway was built to the latter point in 1895. Moreover, as Sandon was several miles nearer to the centre of probable production than Three Forks, the Canadian Pacific line was extended from the latter point to Sandon, thus affording competitive transport facilities, the effect of which has been felt favorably ever since.

It is difficult to get accurate statistics of what the output of silver-lead has been up to the end of 1894, and no comparison can therefore well be made with the output of later years; but the effect of the advent of railways can be imagined. Suffice it to say that not only did the volume of shipments increase, but the cost of operation decreased, while development work received a decided impetus.

It should be remarked, here, that what had been accomplished at the time of the completion of the railways, and even in large measure since then, had been without any extraordinary effort, and without the aid of any large amount of outside capital; indeed, many of the shipping properties had paid "from the grass-roots." It was, nevertheless, beginning to be felt that sooner or later an important part of the output must be won by mechanical means, the present importance of which will be shown hereinafter.

The geological and physical features of the Slocan ore deposits are not germane to our subject, but in passing it may be well to give a brief statement of these. For our purposes we would describe the Slocan District as a ruggedly mountainous area lying west and north of Kootenay Lake and its west arm, east of Slocan Lake, and south of a line extended east from the north end of the latter. In the northern part of this area we find about 100 square miles of the "Slocan *slates*,"* from which by far the greater part of the silver-lead output has been derived. The ore bodies usually cut across the slates, are from a few inches to many feet in width, are probably genetically related to a series of porphyry (felsite) and other dykes, and, besides the usually occuring gangue minerals, which are chiefly spathic iron and quartz, in the case of the larger deposits contain many inclusions of the country slate.†

South of the slates we find a large area of coarse *granite*, in which are many veins of vulue. Those which contain any notable amount of lead and zinc minerals are quite narrow when compared to the deposits found in the slates; but because of the hardness of the granite, the fissures are often much more sharply limited as to their walls, and fewer large inclusions of the country rock are found. The ores are harder and tougher, contain a greater proportion of quartz and spathic iron to valuable mineral, a greater variety of other gangue minerals, and important amounts of the richer silver-bearing minerals, finally disseminated. As in the slates, an important part, and indeed frequently the chief part of the values, is highly concentrated, and is extracted and shipped, with little sorting, as "clean ore."

East of the slates and granite, we find along the west shore of Kootenay Lake, a narrow fringe of very old schists and slates, which, in the vicinity of the town of Ainsworth, carry valuable deposits of good size and apparent permanence. But the ores are of low grade in silver (excepting some which lie near the granite area), and although considerable shipments have been made, they cannot under present conditions yield much, if any, profit.

I have stated above that a large part of the Slocan output has been derived from those portions of the deposits which contained the ore in a concentrated or "clean" state. It will be understood that a vast amount of material has been broken down in this process, which could not be formerly profitably disposed of. This may be somewhat enriched by such small fragments of the clean ore as escaped the miner's vigilance, and was used for filling stopes or placed on dumps, until such times as it could be treated by mechanical means. Such second class ores, together with the parts of the deposits which contained no clean ore, accumulated to an enormous amount, and of late years have formed the basis of operations very important to the district.

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* So named by the geological Survey of Canada: See Mr. McConnell's Report for the year 1895.

† This latter characteristic might better, in some cases, be expressed as a penetration of the fractured slates by the ores.

The experience of most of the mines has shown that the process of hand-sorting, even of the so called solid ore, was at best a very expensive one, and very inefficient. The tendency has thus been toward the adoption of means to cut down the cost and improve the quality of the work, whilst at the same time winning such of the values as would otherwise lie dormant. Latterly, therefore, the proportion of hand-sorted ore to total shipments has declined noticeably.

CHARACTER OF PRODUCT.

The material shipped from the region described, is (*a*) silicious oxidised ore from near the surface of the deposits which are in slate. This product was formerly of important quantity, was often high grade in silver, and carried about 20 per cent. to 30 per cent. of lead; but it is no longer of much, if any, importance, the superficial portion of the veins having in most cases been worked out. (*b*) *Galena.*—This forms now the bulk of product, whether as coarse, hand-sorted ore, or as concentrate. The shipments are still high grade in silver, say, 80 to 100 ozs. per ton, and probably average about 40 per cent. lead. It is impossible to give any average analysis of this material as a whole, but besides the lead, about 12 per cent. of zinc may be said to be present, and of the balance the chief constituents are quartz and spathic iron, which, by reason of the imperfections of all processes, cannot well be eliminated efficiently, *i.e.*, without the loss of too much value or at too great expense. (*c*) *Dry Ores.*—Chiefly silicious, silver bearing material, very low in lead. This class is now derived principally from the granite area, and up to the present, is not amenable to efficient concentration. It is therefore shipped direct to smelters, who employ it is a flux, and as a dilutent of the heavy lead ores in the furnace "charges." (*d*) *Silver-bearing Zinc.*—This is found of high grade in several properties, and some has been shipped either as hand-sorted or as a middle product from some mills, either by itself to European smelters, who allowed payment for the zinc content, or mixed with the galena concentrate after elimination of gangue minerals. The Slocan is affording a gradually increasing amount of this rich zinc, and a satisfactory solution of the problem of realizing on all the values is at present one of our greatest troubles. Not discouraged, however, several of those in charge of plants appear to be approaching a solution, of which it is yet too early to speak.

PRODUCTION.

It is extremely difficult, if not impossible, at this late day, to get accurate figures of production for the first three years of Slocan output. Those given in the "official reports" are essentially Customs returns, and the metal contents of exports have always been only approximately stated. The figures of output since 1894, however, thanks to the careful work of the Provincial Mineralogist of British Columbia, are dependable.

If we refer to the reports of the Minister of Mines of British Columbia for 1894 and subsequent years, we find the basis of the following table or silver lead production in the "Ainsworth" and Slocan mining divisions, which embrace the area which we call Slocan :—

Year.	Ozs Silver.	Tons Lead (2000 lbs)	1 Unit of Lead (20 lbs) contains.... ozs Silver.
1892-94*	1 050,539	4,783	2.20
1895	1,400,070	8,238	1.70
1896	2,328,355	10,686	2.18
1897	4,165,865	17,126	2.43
1898	3,235,795	14,520	2.23
1899	2,159,190	10,125	2.13
1900	2,473,343	11,466	2.16
1901	2,601,172	9,407	2.76
Total	19,414,329	86,351	Av. 2.25

* These figures for these three years are for the *entire* British Columbia output, but as this was essentially all from the region we call Slocan, the figures may be regarded, for our purposes, as sufficiently accurate.

These figures are of much interest to those immediately concerned, and exhibit the effects of certain causes, but for us the main interest centers in the column of ratios of lead to silver. When we explain that in 1895 the ratio is low because the old Bluebell mine was producing a very large amount of lead of low silver tenure, and that in 1901 there was a heavy output of dry silver ores, with concurrent small lead production, the ratio was high, there is a remarkable uniformity in grade of output. A second point of interest is revealed in the average ratio of two and one quarter ounces of silver to each unit of lead. The implies much richer ore than is produced on a large scale in any other district of the Northwest and the richness is still more evident when we state that the ratio in East Kootenay is only one-half of one ounce per unit, and in the Cœur D'Alene district of Idaho, it is somewhat less yet. It should be remembered, too, that whatever ore was produced near the town of Ainsworth tended to reduce the average ratio, which is there about one to one, and the comparisons above made are, therefor, all the more remarkable.

The figures given above tend to show not only a very good reason for the rapid advance of the Slocan, but they indicate important differences between successful concentration in Slocan and in East Kootenay or the Cœur D'Alene, when commercial results are considered. Putting the difference tersely, and assuming that all the silver is contained in lead, a loss of one per cent. of lead in tailings, means in the Slocan, four and a half times as much silver as it does in the other places. The layman will quickly point the moral—"Save your lead"—but just where to stop is the problem for each manager to solve in his own case, and no line or limit can be arbitrarily set, nor can we say that it is not better to save only 70 per cent. in one case than 85 per cent. in another. Millmen throughout the Northwest, confronted by conditions ef very high wages and expensive supplies, may and do often find it best to sacrifice high efficiencies to the better commercial results attained by rapid operation and large tonnages. In a general way this has been proved desirable in Cœur D'Alene, but in Slocan it is not so much so. Our observations lead us to the statement that in many instances the relations of the commercial and technical factors of concentration have not been sufficiently studied before construction has been started. Indeed, it is within only the last two or three years that there has been any considerable departure from the details of mill design, which have been so long regarded as incapable of improvement. The earlier designs followed the Cœur D'Alene practice very closely, with rapid running and low costs as the chief aim. Latterly, modifications have been in the direction of possibly greater first cost, and increased efficiency, without increasing the operating cost, especially in the fine end of the mills.

Coming now to an enumeration of the mills which have been built, we believe that even those who are familiar with the Slocan will be surprised at their number. The mills and years of construction are as follows :—

1—Alamo	1894
2—Washington	1896
3—Slocan Star	1896
4—Noble Five	1897
5—Whitewater	1898
6—Montezuma	1898
7—Comstock	1898
8—Jackson	1899
9—Ruth	1899
10—Wakefield	1900
11—Ivanhoe	1900
12—Enterprise	1901
13—Payne	1902
14—Rambler-Cariboo	1902
15—Pilot Bay	1893 (?)
16—No. One	(?)
17—Woodbury	(?)
18—Highlander	1899
19—Highland	1900

Of these the last four are in the vicinity of Ainsworth, and have treated the low grade ores of that camp. The Pilot Bay mill, in 1895, treated the ores of Bluebell mine. The Washington mill was dismantled during 1901, and the plant rebuilt at the Rambler-Cariboo.

The combined capacity of these plants is probably about 2,100 tons daily, and their erection has probably involved an outlay of well over $500,000. Of the total number only five happen to be in operation at present, while of the remaining thirteen, six were erected, in our opinion, without sufficient justification as to tonnage in sight. The others are not in operation for various reasons which it is hardly necessary to discuss here.

Among so many plants one easily discovers differences of design and operating scheme, and, as might be expected, the technical results obtained probably vary within wide limits. Of the more prominent mills, however, no less than seven were designed and erected under the supervision of one man, who, in outward appearance of his structures at least, has quite naturally followed one general plan, eminently adapted to local conditions; and we may also say that no matter how much we may differ from this designer in detail of scheme, he has been very successful in producing mills which are operated at low costs of labor.

By way of brief description of the process, we would say that the ores are delivered to mill storage bin. From this they pass over only a small Grizzley to Blake crusher, set so that the maximum size of product will be about one and a half inch. With or without an intervening bin, the ore passes through a belt-driven cam feeder to roughing rolls, belt driven, usually not less than 30 in. diameter, nor more than 12 in. faces, running at about 110 revolutions. These rolls discharge to an elevator and thence to trummels, whose screen sizes vary from 21 mm. to 2 mm. Sizes over 2 mm. pass to Hartz jigs, and those under 2 mm. to hydraulic separators, from which, sizes above 1 mm. go to fine Hartz jigs, and those below 1 mm. through spitzkasten to some form of vanner, or other table machine, or, formerly, to revolving single or double-decked buddles. Middling products from coarse jigs are re-crushed by rolls usually duplicates of the roughing rolls, while middlings from finest jigs and the tables are commonly re-crushed in Huntington mills. The concentrate is conveyed by water through launders to a series of bins where it drains, and is put into jute sacks for shipment to the smelter.

The general course of the ore and products through the mill will thus be seen not to differ in any material way from that of other regions where coarse concentration is practised. When we examine into details and results, however, we are forced to the conclusion that better work can be done, and we therefore venture to offer the following comments on the process as now carried on to any who contemplate the erection of concentration plants in the Slocan.

We have remarked above on the high ratio of silver to lead in these ores. This ratio is high not only because the galena, when perfectly clean, is usually high grade in silver, but because of the admixture of gray copper and other rich silver-bearing minerals. These, as well as the galena, are not only soft, but very friable, and what with their tendency to breaking very finely in the crushers and rolls, and the results of attrition on the beds of the jigs, a surprising quantity of rich material soon finds it way out of the mill by illegitimate means, and the vehicle largely responsible is the final overflow of water from concentrate bins and from the spitzkasten, whose settlings feed the vanners or tables. Almost all mills attempt to remedy this evil by means of shallow settling vats placed below the concentrate bins; and in a measure these are useful. Our experience shows, however, but not only is the overflow still valuable, though less in quantity, but that the material saved, on account of the extreme fineness, holds about three times as much water as the normal concentrate, is lower grade in lead and silver, and higher in zinc. The same remark as to quality would apply in greater degree to the overflow from spitzkasten. As to the latter, we may say that in order to reduce losses in this direction, we have returned this overflow in one instance, and concurrently reduced the volume of clean wash water on various machines, with some degree of success; but at best the scheme is only a make-shift, and I believe that we are doctoring this difficulty at the wrong end. We should prevent the evil rather than remedy it, by providing a short sorting belt above the coarse crusher. This need not be over, say, six feet long, would cost little, and could be handled by the crusher tender, whose functions now are chiefly those of a watchman. The sorting belt is practically unknown to the Slocan mill, and without reverting in more than slight degree to the labor-devouring practice ot Europe, I know from experience that in some instances a limited introduction would be a paying one. As indicating the result which may be expected, where the mill feed contains an appreciable quantity of galena in pieces of the size of one's fist, or larger, I may cite an instance at one of the mills of which I am in general charge. In the summer of 1900, our crushermen, under instructions, picked out from the ore stream passing over the grizzley such pieces of coarse galena as they could conveniently, and without any special care. The feed was not sprinkled, and much of the galena which was coarse enough to have been easily sorted on a belt, probably escaped into the crusher. During a period of about four months, 120 tons of galena where thus sorted, equivalent to about 8 per cent. of the total concentrate made in the same period. Comparative average assays of the two products are given; viz:—

	Silver.	Lead.	Zinc.	Ratio.*
Sorted Galena........	101.7 ozs.	40.2	15.4	2.53
Concentrates.........	73.0 "	30.0	21.0	2.43

For this galena we received from the smelter about $670.00, and had it been sent through the mill in the usual way, it is safe to state that fully 10 per cent. would have been lost.

It cost us nothing to save that 10 p.c. How much more could have been saved by the aid of proper appliances I do not know; but there is no doubt about the accuracy of the data, nor, I think, of what they indicate.

Another notable feature of our mills is the absence of any general attempt at close sizing before jigging. In this respect we follow the common tendency of the Northwest, and more particularly the Cœur D'Alene, unless the practice of that region has changed since I was more familiar with it than I am at present. In many places the low grade of ore demands, or it simplicity permits, good results to be obtained without that close sizing which our German friends formerly thought essential, but about which American authorities have had considerable differences of opinion. There is no doubt in my mind, however, that Slocan mills cannot do efficient separation without close sizing. An extreme instance is often more likely to impress one than a normal case of difficulty. I therefore give the following:—

At the Whitewater mill the feed consists essentially of slate, "talc," zinc blende, copper and iron pyrites, gray copper, quartz, calcite, spathic iron and galena. At our Enterprise mill the slate is replaced by granite, and we find, beside the Whitewater minerals named, important quantities of complex carbonates of iron, lime manganese and magnesia, some undetermined manganese zinc iron compounds, probably silicates and oxides, to say nothing of the rich silver minerals and native silver. Now were our gangue minerals all simple and of low specific gravity, we would consider our way easy, and have little difficulty in doing respectable work with a simple screening system. The presence of all the minerals above named is of course troublesome, but these obstacles to success are not insuperable. When we begin a proper study of conditions at Whitewater, we are stunned by the discovery that "galena" is not galena at all, for it is a mixture, I might say a concrete of comminuted slate, galena and zinc, with occluded particles of several of the gangue minerals named, the whole having a gravity of 4.75 to 5.25. This is so typical of the Whitewater mine that shipments of large quantities of well hand-sorted product, before our mill was built, shewed an average content of about 35 per cent. of lead and 16 per cent. of zinc, equivalent to, say, 40 per cent. galena, 24 per cent. zinc blende, and the balance, or 36 per cent. virtually barren gangue. Galena of a gravity of 5.0, and barren pyrites of a gravity of 5.0, mixed with barren blende of a levity of 4.5, form a sort of ore dressing joke whose density is so great that one cannot laugh, with any enjoyment, and hold one's position at the same time. It appears to me that the only satisfactory way of solving such difficulties as are implied above, is through a more extended screen system than we employ. I am not prepared to say that we should go to the extreme limit of some German practice, but I do think that our mills should be designed with what one may call a greater limit of elasticity, one which will permit rapid and convenient alteration or extension of the screening department. The day has gone by when the man who wants a mill should go to a drawer and pull out a stock plan labelled with a specific tonnage capacity. Certain essential features of mill construction must always remain the same, but each new case of installation must have its details considered by themselves. Granting conditions of well sized feed, and a uniform quantity, I think the Slocan jig practice very efficient. The feed above 3 mm. in size usually forms nearly 80 per cent. of our tonnage although more nearly 30 per cent. of our values reach the fine jigs and tables. Indeed, in one instance the jig tailings were all eventually crushed fine enough to reach a row of seven Wilfley tables, I believe with results which were good. Here, of course, a smaller percentage of product was made on jigs. The usual run of jig tailings seldom contains more than one-third as much silver as the fine end tailings do, and often it happens that the work of the coarsest jigs is practically perfect. This is due in large measure, in some cases at least to the inclusion of coarse slate, quartz and calcite in the ore, all of these being generally barren of silver.

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* Of ozs. silver to one per cent. lead.

The fine end of our mills certainly aflords room for very great improvement. In the mills which were built from 1896 to 1899, the most common machine used on the finer feed were double-decked revolving buddles, and although some are still in evidence, the majority have been replaced by other types. There are several reasons for this change, especially where the very finest pulp was being treated: 1st. the buddle was handicapped by imperfect classification of feed; 2nd. the wooden surface seemed to accumulate some vegetable slime which permitted the metallic minerals to escape too soon, and 3rd. in cases where volume of water was a consideration, it was found very wasteful. The buddle advocate has accused us of ignorance as to how to work that machine. This may be just, but the fact remains that, in one mill, an extended comparison, on feed as nearly identical as possible, resulted in a saving of 300 lbs. more of a much better product, in 24 hours, with about one-tenth of the volume of wash used, the single decked table used occupying only one half the floor space of the double decked buddle.

The unsatisfactory work of classifiers, of course, operates against any concentrating machine, and we still have troubles to overcome in the fine end, which no number of machines of existing types will bring about. Some one will always get a portion of what the proceeding one failed to secure, so we are compelled to set a limit to plant which is governed by questions of dollars and cents. Slocan seems to have discovered that, on account of the excessive cost of machinery and installation, it does not pay to try to save more in the fine end than can at present be recovered by one passage of pulp finer than half a millimetere over well known machines of proved merit. Attention is, however, being paid to slime treatment, and some very careful experimental work conducted, which is so encouraging as to cause us to say that the close of this year will witness our probable ability to make an efficiency of well over 85 per cent. in silver a paying one.

This brings us naturally to what the present efficiencies are, and the subject is a delicate one. Aside from the fact that there are many millmen who. through false reasoning, would not confess to high losses, I believe there are more who do not know their actual losses, because of the common absence of automotic sampling devices for the tailings, and the too frequent use of the fire assay instead of the wet, in determination of lead. There is too much of a tendency among mill men to assume that, because they cannot see galena, for instance, in tailings, the best possible work is being done. This assumption is, I think, a commercially justifiable one in many cases, but it affords no good reason for not knowing, instead of guessing, at losses. Personally I consider an accurate sampling of tails, and wet lead tests, of the greatest importance, in the Slocan, and especially where much slate is present in the feed.

To illustrate the importance of the wet assay for lead, I may say that a series of important trials of pulps show a loss by fire method of from 70 per cent. to 100 per cent. of the actual lead present, when the wet test shows, say,, under 2 per cent. in the sample, and in a recent trial the wet test showed 1.36 per cent. and 1.42 per cent. the fire assay none. The feed from which these tailings were derived contained 4.7 per cent. and 5.2 per cent. lead respectively, and the fire assay therefore, perfection in the mill work, while the wet test gave efficiencies of 71 per cent. and 73 per cent. only. These results would be slightly improved, of course, if the tailings losses were worked out per ton of feed, but the figures illustrate our point; viz., not to deceive ourselves through wrong method of determining our efficiency. I do not pretend to know what degree of perfection is attained by others, but our own experience shows an actual recovery of 74 per cent. of silver and 82 per cent. of lead, from a feed of 10 ounces silver and 4 per cent. lead. Those who are not familiiar with the shortcomings of existing types of concentrating machinery in use on a large scale and those who do not care to know how poor a quality of work may be done, will regard these efficiencies as wickedly low. I am confident, however, that thorough investigation would show them to be excellent under the circumstances.

COSTS.

The operating costs in Slocan mills are, as everywhere, very much dependent on the tonnage treated, but the cheapness of our power is an important factor, The ruggedness of the mountains permits convenient installation of small water power plants, working commonly under heads of three of four hundred feet, and while in some instances sufficient, if any, gaugings of flow have not been made before location of plant was decided upon, to determine the dependable volumes, heavy snow-fall, and even the presence of glaciers at the head waters, insure sufficient water throughout the year on lateral creeks, at points very close to many of the mines, It is not necessary to dilate on this phase of the facts; suffice it to say that none of the mills except two on Kootenay lake have any steam power plants. Most of the plants are designed with a view to saving of labor, and are compactly arranged. Their efficiency in this respect may be seen from the table of costs below, being results attained in operating one of the more prominent mills:—

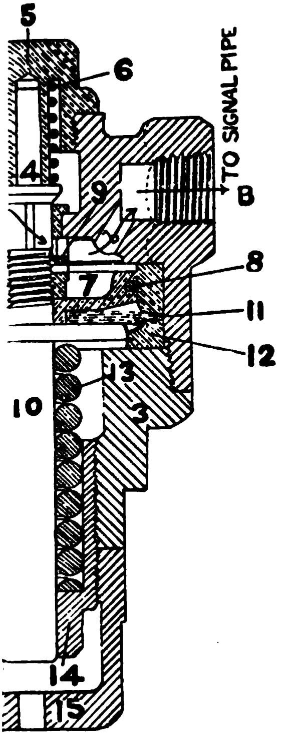
Period, 557 days of 22 hours.
Tons of feed milled, 100,824 (including 7 per cent. moisture).
Tons milled per day, 181.

Costs.	Per Ton.	Per Day.
Crushermen	$.0364	$6.59
Foremen, jigmen and tablemen	.1613	29.19
Miscellaneous labor	.0223	4.04
Operating supplies	.0248	4.49
Maintenance and repairs of all plant; labor and material	.0958	7.34
	$.3406	$61.65

These costs do not provide for depreciation or insurance, the amount of which is of course largely a matter of judgement and conditions. The cost of maintaining the flume was 15/100 of one cent per ton, and thus practically a negligible account. It will be noted that the above figures make no provision for handling and disposal of product, The cost of this in the table would have added $0557 per ton of ore, but as the figure depends upon the richness of the ore, these costs of sacks and sacking are placed by us under another head, or are stated as so much per ton of product, (in this instance 56 cents). In this plant two hours are allowed every day for the common light repairs, and the practice has proved a good one in preventing many annoying shut-downs. We believe that with the tonnage treated, these costs would be difficult to lower, and they are given as an indication of what has been none on a large scale, without fear of serious adverse criticism.

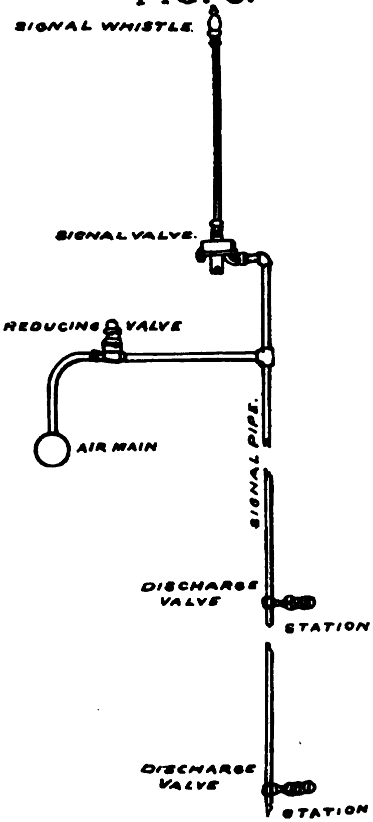
ssland.

G. 2.



VALVE.

FIG. 5.



combinations conformable with the code used.

The signals are transmitted from any level in the mine by pulling

Mine Signalling by Compressed Air.

By Bernard MacDonald and Wm. Thompson, Rossland, B.C.

In mining operations the problem of signalling from the mine workings to the engineer running the hoisting engine on the surface is receiving more thought than formerly, This is due to the rapidly increasing depths of mine workings, and to the fact that the devices now in general use render signalling from considerable depths unreliable.

The system in general use is known as the pull bell system. The mechanical appliances used in this system consist of a marine gong or other sounding apparatus, called the bell, a rope, called the signal rope, a device for deflecting the direction of the signal rope, called the bell crank, and a counterbalance for the weight of the signal rope, called the balance bob.

The bell is located in the engineer's room, or within ear-shot, and generally within convenient sight of the engineer.

The signal rope is attached to the bell and carried to the collar of the shaft, thence down it to the deepest workings from which it is desired to transmit signals to the engineer at the surface.

The bell crank is a triangular lever, placed at the collar of the shaft, or at any other place, where the direction of the signal rope is changed.

The balance bob is placed at the collar of the shaft, or at suitable distances apart in it, to balance or slightly overbalance the weight of the signal rope. It is fulcrumed as a beam, the signal rope being attached to one arm, while the other arm is weighted as mentioned.

Balance bobs are sometimes substituted by spiral or coiled springs to produce the same effect.

The signals for hoisting or lowering men or material, or telling what is wanted by the workmen below are given by the bell, in the form of strokes and pauses in singles or in any alternating series or combinations conformable with the code used.

The signals are transmitted from any level in the mine by pulling the signal rope, as the signal code requires. The arms of the bell crank, to the ends of which the signal rope is fastened, extend outwards from a fulcrum pivot at right angles to each other.

In the case of an incline shaft the arms of the bell crank radiate from the fulcrum pivot at an angle to each other equal to the angle the dip of the incline shaft makes with the horizon.

A convenient combination bell crank and balance bob is often made in one piece. The balance bob and the bell crank extend as little as is necessary into the shaft, and are boxed in as securely as the conditions will admit, in order to prevent accident in case of pieces becoming loose and falling down the shaft.

The signal rope is preferably a wire one, but plaited cotton or hemp rope is of common use. Twisted rope is not suitable on account of the alternate stretching and shortening that would result from the pulls necessary to transmit the signals.

The signal rope is kept from sagging or swinging into the shaft by staples or otner fastenings driven into the timbers in the corner of the shaft.

The balance bobs are so weighted as to overbalance by some 10 or 15 pounds the dead weight of the signal rope. Overbalanced thus, unless interfered with by some other causes, the signal rope returns promptly after each pull to its normal position in a state of rest. This device facilitates and makes possible the transmission of signal strokes to the bell at the surface from the workings of the mine.

Separate installations similar to that described are made for each shaft compartment through which hoisting is to be done, and to avoid confusion to the engineer, or mistakes, the gongs or sounding apparatus on the surface have different tones, and are frequently placed at considerable distances apart, and toned in this way the engineer is less likely to mistake from which compartment the signal was transmitted.

SIGNAL CODE.

That which remains yet to be said about the pull bell system of signalling may be better understood if one of the signal codes in common use is given below for reference.

General.

1 Bell, hoist.
1 " stop, if in motion.
2 Bells, lower.
3 " warning that men are going aboard, and that the cage is to be hoisted or lowered according to the signal to be given subsequently.

Station Signals.

2 Bells, pause; 2 bells, pause; 2 bells, to station at surface.
1 Bell, " 1 bell, to station at 1st level.
1 " " 2 bells, to station at 2nd "
1 " " 3 " to station at 3rd "
2 Bells, " 1 bell to station at 4th "
2 " " 2 bells, to station at 5th "
2 " " 3 " to station at 6th "
3 " " 3 " to station at 7th "
4 " " 1 bell, to station at 8th "
4 " " 2 bells, to station at 9th "
4 " " 3 " to station at 10th "

DEFECTS OF THE PULL BELL SYSTEM.

When the mine workings are shallow and there are but one or two hoisting compartments, the pull bell system of signalling works very well, but when any considerable depth is attained, or where there is more than one hoisting compartment and the traffic is heavy and from various levels, the defects of the system become apparent.

The primary cause of most of the defects is the fact that all the parts of the apparatus are moving parts, having to reciprocate to each other for every pull given by the signal sender. It will be readily understood how an apparatus constructed with a large number of reciprocating parts extending through vertical or inclined shafts to depths of over 1000 or 2000 feet may become deranged and out of order.

One of the greatest defects of the system is that the signal sender cannot know whether the signal he sent to the engineer has been properly transmitted and reported by the bell, as the bell strokes cannot be heard at any considerable depth in the mine. Then, at any time one or more of the numerous parts of the apparatus may become deranged and cease to work during the transmission of a signal, and the part of the signal sent before the derangement occured may, in itself, be a complete signal, conveying to the engineer an entirely different signal from that which was intended. If the erroneous signal thus received be acted upon by the engineer, an accident to life or machinery might result.

Again, the apparatus might become deranged by expansion or contraction of the signal rope. In the case of a wire rope this might result suddenly from the rise or fall of temperature in the shaft due to change of air currents in the shaft from an upcast to a downcast, or *vice versa.* In the case of a cotton or hemp rope, the alternate wetting and drying, not uncommon in shafts, would have the same effect. The devices for fastening the balance bobs or for retaining the signal rope in one corner of the shaft are liable to become broken or destroyed by wear or accident, and the rope sag or swing into the shaft, where it would be likely to be caught and carried away by the ascending or descending cages. The numerous defects to the pull bell system of signalling mentioned become more accentuated when the system is operated through an incline shaft.

On account of these defects, a number of electric signalling systems have been devised, from time to time, and tested. While some of these have shown considerable merit, in certain ways, over the pull bell system, nearly all of them demand the use of apparatus too delicate for the rough usage and conditions inseparable from mining operations. These reasons and the lack of simplicity of construction which permits of extension, maintenance and repairs of the apparatus by men lacking technical training constitutes a serious defect in the otherwise best of the electric systems.

The defects of the pull bell system became painfully apparent to the writers when they underlook the installation of a signalling system in each of the four hoisting compartments of the Le Roi combination (incline) shaft. If the pull bell or electric systems were installed, the four bells representing the four compartments would have to be in the room with the two hoisting engines. With the possibility of four bells ringing at once, confusion and mistakes would be inevitable. In devising ways to overcome this difficulty, it occurred to us that since the signalling between the conductor and engineer of express trains is now carried on most satisfactorily by compressed air, it would not be more difficult to obtain equally good signal service by the same system through the combination shaft.

With this object in view, correspondence was opened with the Westinghouse Air Brake Company, of Philadelphia, the patentees of the air system used on trains. Being informed that the apparatus of the system was obtainable, and of moderate price, it was purchased and installed in two of the compartments of the combination shaft, in the month of February, 1900. The system was a success from the start, and has been in continuous operation ever since, giving perfect satisfaction without any expense for maintenance or repairs. Recognizing its superiority over the pull bell system described, and believing that its adoption where the circumstances are suitable will add another improvement to mining equipment, the following detailed description of the apparatus and its cost is given.

THE COMPRESSED AIR SIGNAL SYSTEM.

The apparatus of this signalling system is the same as that used by express trains, with some slight modification in the installation. Fig. 1, 2, 3, 4. and 5 accompanying show the details, of the apparatus used, all of which may be purchased from the Westinghouse Air Brake Company.

The *Whistle*, Fig. 4, is the sounding device which conveys to the engineer the signal sent from the mine workings. This is located in the engine room, and where signals from more than one source are received each whistle may be tuned or chimed differently from the other, so the engineer may readily distinguish the source from which the signal is sent.

The *Signal Pipe*, Fig. 5, is ½ or ¾ inch in diameter, and must be used exclusively for signalling purposes. It connects with the whistle down to the deepest workings in the mine. Signalling apparatus may be fitted in this pipe at any intermediate points desired. In fitting this pipe care must be taken that no leaks exist, for the smallest leak would destroy the working of the system.

The *Signal Valve*, Fig. 3, must be placed at some point in the signal pipe where there is no danger of freezing—close to the hoisting engine would, perhaps, be most suitable. This part of the apparatus consists of a mechanical device containing two compartments "A" and "B", separated by a diaphragm 12, and the diaphragm stem 10, attached thereto extends through bushing 9, its end forming a valve on seat 16, over port (e.) a small portion of the diaphragm stem 10, fits bushing 9, snugly, while just below its upper surface a peripheral groove is cut in the stem and its lower end is milled in triangular form, signal valve is attached to main signal pipe at Y, where pressure enters, and passing through port (D) charges chamber "A", and through port C, past stem 10, charges chamber "B".

A sudden reduction of pressure in the signal pipe reduces the pressure on top of diaphragm 12, in chamber "A," and the greater pressure in chamber "B" acting on its under surface forces diaphragm upward and momentarily permits portion of the air in the signal pipe and chamber "B" to escape to the whistle, thus sounding a signal to the engineer as often as the discharge valves are opened at any one of the stations.

The *Reducing Valve*, Fig. 2, is inserted in the feed pipe that connects the compressed air mains of the mine with the main signal pipe of the system. The regular mine pipes should be connected by suitable piping at outlet "A," and other piping extend from outlet "B" to the signal pipes, in which the maximum pressure should be 40 pounds per square inch. As this pressure is reduced by signalling piston 9 rises under pressure from spring 13, and forces supply valve 4 from its seats, when pressure from air mains entering at "A" passes through valve 4 to chamber "C" and through port (b) to the signal pipe at "B." The pressure therein being restored to 40 pounds, piston 7 is forced downwards by air pressure and valve 4 is seated by spring 6, shutting off further supply of air until another signal has been sent, releasing pressure contained in signal pipe.

The *Discharge Valve*, Fig. 1, is inserted in the signal pipe in close proximity to the signalling station so the sibilant sounds of the air discharges may be easily heard by the signal sender. The importance of this lies in the fact that the discharge sounds give assurance that the signal has been delivered to the engineer on the surface. A branch pipe should extend to the main signal pipe and a valve set between the discharge valve and main signal pipe, to permit repairs being made to discharge valve at any time.

A moderately light cord should be attached to the discharge valve at lever 5, and extended to within easy reach of the operator.

With each pull of the cord lever 5 pushes open valve 3, permitting a small quantity of air to escape from the signal pipe, and causing the signal to be transmitted to the engineer in the manner described.

COST OF INSTALLATION.

The apparatus required in the engine room consists of

1 Small whistle, Fig. 4, cost	$1 25
1 Reducing valve, " 2, "	4 50
1 Signal valve, " 3, "	6 00
Total cost	$11 75

The entire cost of an installation to a depth of 1,000 feet, with signalling stations 100 feet apart, would be $127.50, made up of details as follows:—

Engine room part of apparatus, as above	$11 75
Sufficient ¾″ pipe to connect from engine room to collar of shaft—say 100 ft	5 00
Labor installing (1 day, fitter and helper)	6 50
11 Discharge valves, located one at collar and one at each working station, cost each $2.00	22 00
11 ¾″ Common globe valves, 75c. each	8 25
1,000 feet of ¾″ common iron pipe	50 00
50 Wrought iron hangers, 5c. each	2 50
Labor installing (1 fitter, 2 helpers—2 days)	19 00
10 pounds ¼″ dia. cotton bell cord, at 75c	2 50
Total cost of equipment ready for service	$127 50

OPERATION.

Signals are given the engineer from any station or signalling point in the mine workings by a quick short pull of the signal cord attached to the lever of the discharge valve. Such pulls momentarily reduce the pressure in the main signal pipe and transmit an impulse on the column of air contained therein, the effect of which is to automatically operate the signal valve and discharge a small quantity of air through the whistle, sounding a sharp, clear blast, corresponding to each pull of the cord. Each whistle blast in the engine room is represented by a sharp discharge of air from the discharge valve, which gives to the signal sender the means of accurately checking the signal sent in.

Signal blasts may be given at the rate of two per second,—in fact, this rule should be generally observed, as long discharges of air at the signal valve are not only unnecessary, but likely to confuse the engineer.

In case the supply of compressed air is likely to be shut off at any time, this system might be supplemented with the pull bell, or some of the electric systems of signalling.

THE ADVANTAGES OF SIGNALLING BY COMPRESSED AIR AS COMPARED WITH THE PULL BELL SYSTEM.

In the apparatus for signalling by compressed air there is only one moving part, viz , the lever of discharge valve, whereas in the pull bell system all the parts are of necessity moving parts, being obliged to reciprocate to every pull of the signal rope given by the signal sender. The advantage lies obviously with the apparatus having the least number of moving parts, as every moving part is subject to wear and disorder, which is costly to maintain and repair, and unreliable in operation.

Another very important advantage with the compressed air system, is the fact that the signal sender has always the means of knowing whether the signal sent by him has been delivered to the engineer. Changes of temperature, likely to occur from change of air currents, do not effect the working of the system. If any accident should injure the signal pipe or any other of the apparatus of the system, warning would be given at once to the engineer, so the injury could be rectified at once.

In the matter of costs for maintenance, the compressed air system has undoubted advantage of any other system. This system has been established and in operation for about 17 months at the Le Roi Mine. and during this time has required no repairs whatever.

Nickel Deposits in New Caledonia.

By Major R. G. Leckie, Sudbury, Ont.

New Caledonia is a large island lying in the Southern Pacific between 20° and 22° south latitude and 161° and 164° east longitude. Its greatest length, 248 miles, runs from northwest to southeast and its width at the narrowest point is a little over 30 miles.

The coast line is very irregular and is protected almost everywhere by a barrier of coral reefs more or less distant from the shore. Frequent openings through these reefs lead to good harbours and safe anchorage for vessels of the largest class.

The interior of the island being mountainous and roads very limited, transportation of goods and passengers is carrid on chiefly by small coasting steamers which find comparatively calm water behind the protecting reefs.

No systematic geological survey of the island has yet been made, and in this the Government appears to be unaccountably remiss.

The shipments of ores and minerals constitute fully one half of the total value of the island's exports, hence the development of the mineral industry is of the highest importance.

The gneises and mica schists of the older formation are strongly developed in the northwest and upon these rest the sericite and talc schists and crystalline limestone of the Silurian. The peridotite has overflowed these and in the derivative serpentine the ores of nickel, cobalt and chrome are found.

Dr. T. Sterry Hunt in describing the Canadian serpentines says: (Report Geological Survey of Canada, 1863, page 472) "The serpentines of the altered Silurian rocks in Eastern Canada, often form vast masses, almost without admixture. The almost constant presence of small portions of oxyd of chrome and nickel is to be remarked in the analyses, not only of these serpentines, but of the other magnesian rocks of the region." This description will also apply to the serpentines of New Caledonia, although they are more highly impregnated with these metallic oxides, than those of Canada, and both are characterized by the constant presence of grains of magnetic iron.

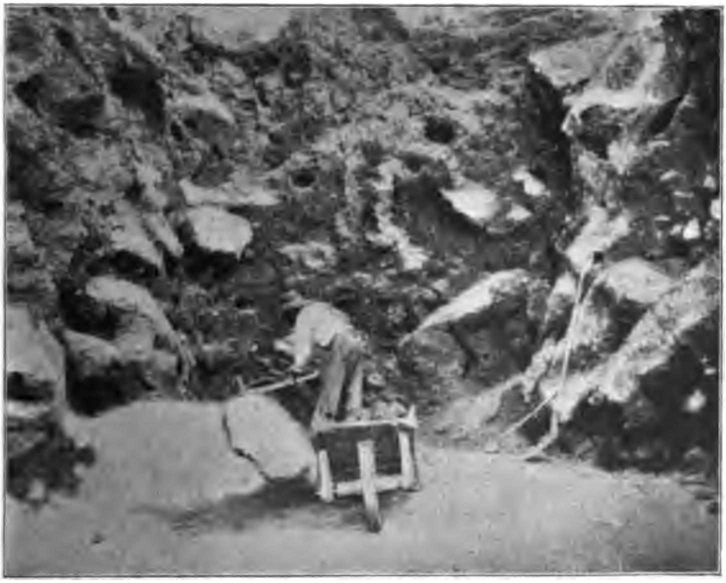
Olivine appears to be constantly associated with these ores in New Caledonla, Canada and Oregon. But it also accompanies the nickeliferous iron of meteorites. Nordenskiold gives the analysis of a meteorite now in the Stockholm museum which contains 40.98 olivine. It was also determined in two meteorites which fell in Brazil as well as in that which fell in Kanzas in 1890.

Mr. F. Danvers Powers notes the presence of nickel in the olivine associated with the new Caledonia serpentines; "Certainly the nickel seems to favour the olivine, and that mineral on account of its numerous cleavage faces, is susceptible of attack." Dr. Sterry Hunt likewise remarks; "The olivine from this locality, like the accompanying magnesian minerals, contains traces of oxyd of nickel." So that the nature of the great serpentine band of the Eastern Townships, is in most respects identical with that of New Caledonia. Likewise the economic minerals found in both are the same; nickel, chrome iron

Working Face with Ore Piles and Waste Rock.

and asbestos, but the latter in New Caledonia is too brittle and short in fibre, to be of any commercial value. On the other hand cobalt occurs in paying quantities in New Caledonia, but so far has not been discovered in the Canadian serpentines.

In a paper read by Dr. A. R. Ledoux before this Institute two years ago, he describes the occurrence of nickel ore in Oregon, under conditions precisely similar to those prevailing in New Caledonia. These deposits however cannot be compared in extent and richness with those of New Caledonia.



Face showing Crevices from which Ore is picked. Waste Boulders.

The rocks of New Caledonia have been subjected to severe seismic disturbances, in which the serpentines have been fissured and broken. This shattering has facilitated the disintegration and decomposition of the rock, into the cracks and crevices of which the original metallic constituents have segregated. From these the nickel ore of commerce is dug. Occasionally viens are met with having a width of from six inches to two feet but they are not found to be persistent in either length or depth. They are usually filled with boulders of the enclosing rock cemented together by a rather higher grade of the nickel silicate. In other places the ore forms a covering to the rock, which gradually gives place to the scattered seams, but in no place does the ore extend beyond a depth of from fifteen to twenty feet from surface.

Pisolitic iron occasionally forms a heavy covering to the ore. It yields when dried from 50 p.c. to 60 p.c. iron, 3 p.c. to 5 p.c. chromic oxide and is practically free from phosphorous and sulphur. Immense fields of this exist.

Ore Train Neponi.

Mr. Thomas Moore, an accomplished chemist and metallurgist of Noumea, and Government Assayer, has made numerous analyses of these ores, which occur as a hydrated sesquisilicate of nickel, varying in nickel contents, as that metal is more or less replaced by magnesia, ferric oxide and alumina.

These ores were first discovered about thirty years ago by Mr.

Jules Garnier and were shortly after named Garnierite. For some succeeding years attention was directed entirely to the green coloured ores and these were dressed up by hand to a value of 12 p.c. to 15 p.c. nickel. The brownish coloured, or what is locally called chocolate ore, has been thrown away as waste, but upon investigation it was discovered that this contained a large percentage of nickel and since then, it has constituted the bulk of ore shipped. The shipping ore is usually brought up to an average tenour of from 7 p.c. to 8 p.c. nickel, dry, that is after the hygroscopic moisture has been evaporated, which varies from 10 p.c. to 25 p.c. The following is an analysis of what may be considered a fair sample.

Silica	43.00	
Sesquoride of chrome	0.50	
Peroxide of iron	14.00	
Alumina	1.50	
Magnesia	21.00	
Protoxide of nickel	9.00	(metallic nickel 7 p.c.)
Protoxide of cobalt	0.25	
Moisture	11.00	
	100.25	

Large quantities of much higher grade ore are mined, but these are mixed with the lower grade mineral to maintain something like a general average.

The rugged mountain range which forms the backbone of the island rises into peaks ovet 5,500 feet in height which are composed of serpentine and the original rocks from which it has been derived. Ore is not found on the higher elevations but on the flanks and spurs which descend to the coast on either side.

From the nature of the deposition of these ores, they are spread over a large area, but confined to a comparatively shallow zone; seldom going below an average depth of from fifteen to twenty-five feet. Therefore the extent of these individual deposits can be approximately ascertained by costeans and shallow trial pits. The ore occurs in a more concentrated condition near the tops of these mountain spurs. Hence the invariable custom followed in New Caledonia of attacking first the upper parts of these deposits, as they can be more readily worked and yield a larger proportion of shipping ore.

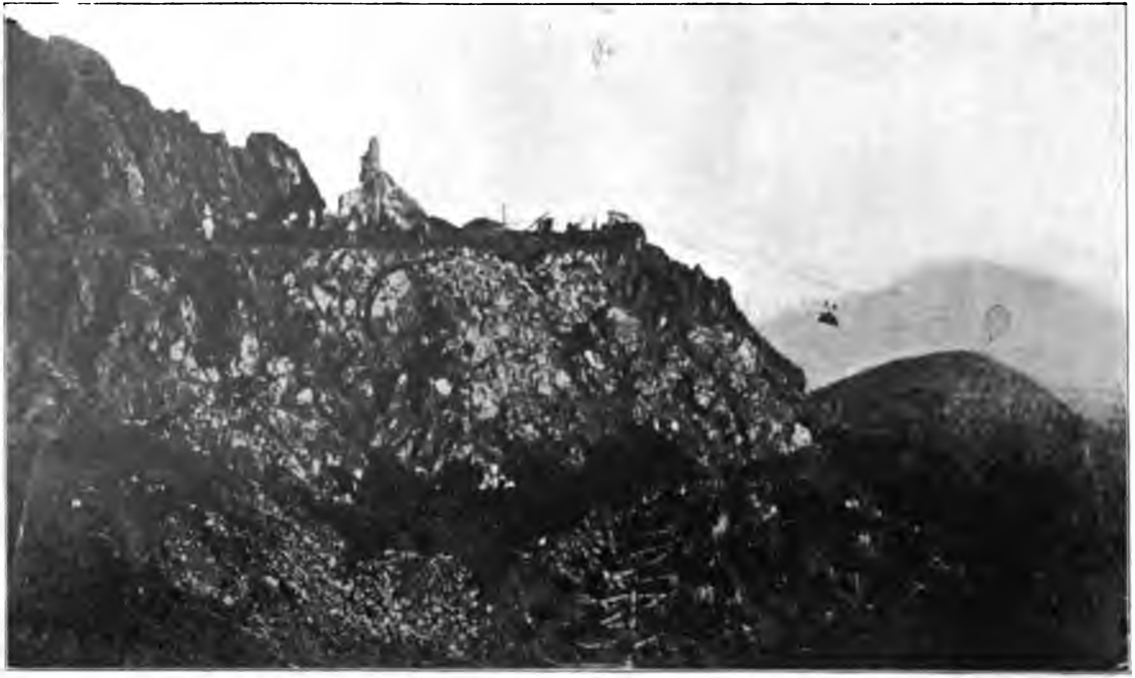
This is a practice objectionable in two ways, as, at the beginning, the mine is robbed of its richest ore, which ought rather to be worked proportionately with the lower grade mineral. Then in operating, the waste and debris are thrown down below. where frequently these have to be moved again in order to open up the lower and poorer benches. It is evident that the proper way to work these ore deposits, is to prospect the ground thoroughly, then remove all available ore from the lowest bench first, after which the waste from the next bench above could be thrown into the lower excavation, and so on with each ascending bench or terrace. A certain proportion of the richer ore from the upper part of the deposits, could be mixed with the lower grade, to bring up the average tenour of shipment.

Pisolitic Iron Ore covering Ore Ground. (F. Danvers Power)

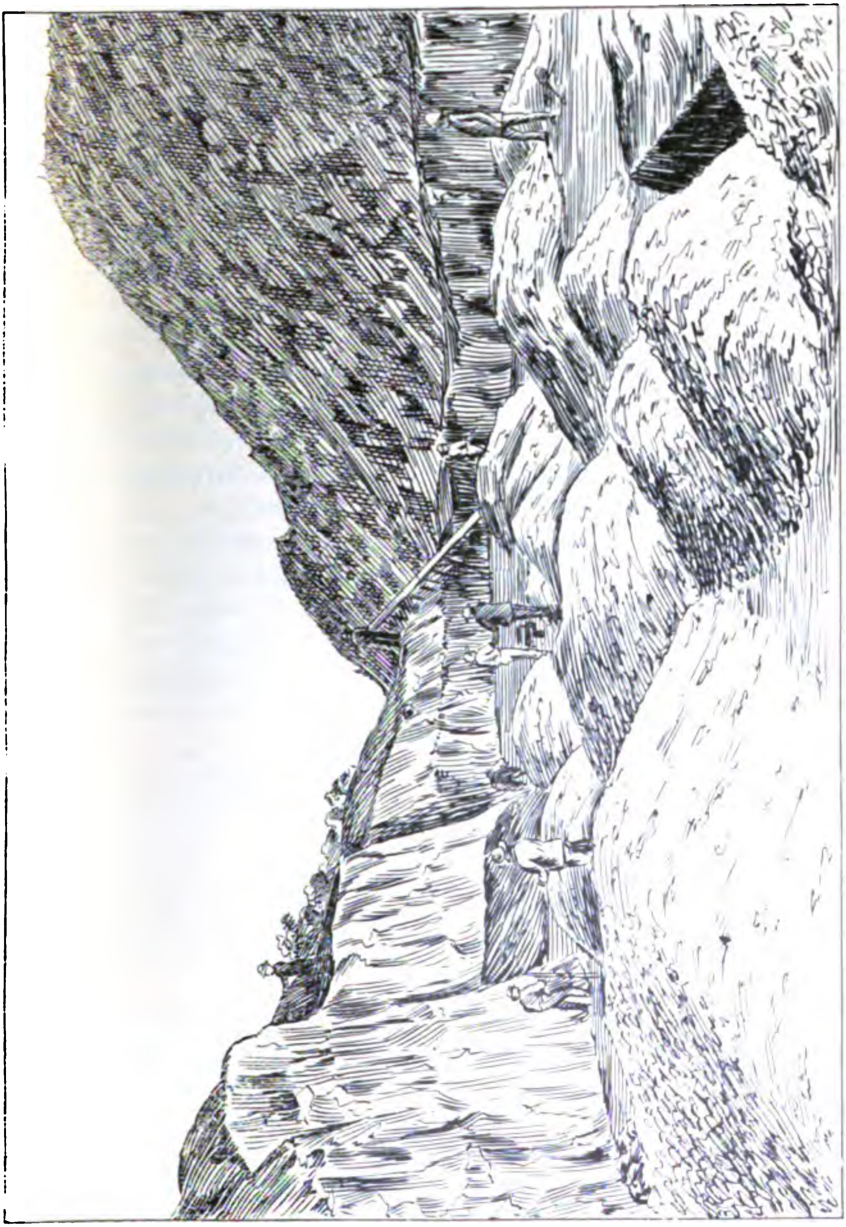
In mining these ores no blasting is required, as the shattered and decomposed rock yields readily to pick and shovel. The ore is gathered into piles, then sampled and analysed. A ticket is put on each pile showing its grade, so that when shipped a proper mixture may be made, ensuring an average of not less than 7 p.c. nickel The waste dumps usually carry 3 p.c. to 4 p.c. nickel, but from the nature of the ore, no mechanical means has yet been devised by which the metal can be saved. Smelting is the only successful method of so doing, but the cost of fuel, flux and labour limit this treatment to ores yielding not less than 5 p.c. nickel, while it does not pay to ship ores of less than 7 p.c. tenour.

The mines of Le Société Nickel have been worked for nearly 20 years and apparently the present output can be maintained for many years. The International Nickel Company has acquired some extensive and valuable properties near Bouloupari; for instance one deposit on the Perle de Koa concession carries upwards of 400,000 tons of ore by actual measurement. Ten years ago, a few hundred tons were

Mine Surprise—showing Working Terraces.



Mine Surprise—showing Working Terrace and Bucket travelling on cable.



Nickel Mine near Dumbea, with Ore Piles. (F. Danvers Power)

shipped from there which averaged 10 p.c. nickel and a sample taken from the remaining waste dump yielded 6 p.c. of that metal.

The Vorarlberg concession adjoining, has an area of 7,286 acres. It has been prospected by costeans aud trial pits over a considerable portion of its surface.

Samples from innumerable openings were taken which showed that almost inexhaustibe quantities of ore of shipping and smelting grades exist, capable of themselves to supply the present world's demands for many years to come.

The ore is taken from the piles referred to and dumped into a bin, where the various grades are pretty well mixed, so as to average about 7 p.c. nickel. From this bin two wire ropes are stretched to the tramway below. The buckets which travel on these ropes, are connected by a light wire rope, which passes over a horizontal pulley, regulated by a brake, so that the loaded bucket hauls up the empty one.

At the Simon Mine near Dumbea, a single wire rope is used. The ore is filled in sacks which are slung to the hook of a free pulley and let go. These travel at a terrific speed until nearing the end, where the sag of rope causes a slight upward incline and finally the sacks are arrested by a strong buttress of wild grass which forms something of an elastic cushion. The pulleys are returned to the mine by pack horses.

The production of nickel during the last few years has ranged from 110,000 tons to 140,000 tons which is all shipped to Europe and the United States. No ore is smelted in New Caledonia although experiments attended with considerable success have been made by M. Caulry of Noumea. The ore is particularly well adapted for the production of ferro-nickel, as it is entirely free from sulphur and phosphorous.

The fonde or alloy produced averaged 55 p.c. to 60 p.c, nickel, 4 p.c. to 5 p.c. carbon with a little silicon and the balance iron. The slag was practically a mono-silicate of magnesia, lime and iron, and although rather viscid from the amount of magnesia present (22.02 p.c.) proved fairly clean. The nickel ran from 0.10 to 0.40 p.c. The consumption of fuel was however high, being accounted for in some measure by small furnace and light burden. Cold blast was used.

The labour problem is the most difficult to solve. The Natives are quite useless as labourers, but the Kanakas from the Loyalty Islands are good workers and easily controlled. The French libérés, or ticket-of-leave men, form a very unsatisfactory class of employés. Coolies from Pondicherry, and Chinese from Tonquin have been imported, but they have proved inferior to the Chinamen from more northerly provinces. Japanese have been brought in by contractors in considerable numbers. The contracts are very exacting, and the inspectors sent over by the Japanese Government are a constant source of friction on account of their own requirements, and demands on behalf of their countrymen. Over a hundred Dalmatians have been engaged within the last two years. Although paid much higher wages their labour is more economical and altogether more satisfactory. Free white men are employed only as superintendents and foremen.

It may be added that from this same formation in New Caledonia there were exported in 1901, 2,872 tons (metric) cobalt ore, averaging 4 p.c., 16,585 tons of chrome iron and 132,098 tons nickel ore.

The population of the Colony according to the latest census returns is 54,415, made up of 12,253 free, 10,506 of the penal classes and 31,656 non-European.

Comparison of Costs of Compressing Air with Steam and Electricity at Rossland, B.C.

By Mr. Wm. Thompson, Rossland, B.C.

Compressed air has become so generally used in connection with mining operations, and is so well recognized as the most usefu land economical power, with its unlimited range of uses, and special adaptability to underground work, that an introductory to this paper on the subject would be superfluous to mining engineers.

The comparative economy of prime movers for air compressing engines is, however, of great interest to all, and a subject on which any engineer can read with interest. This is particularly the case with engineers practising in British Columbia, where a large number of the mining problems include the extraction and reduction of large bodies of low-grade ores and the consequent necessity for a thorough study of economical methods for mechanical handling.

The general mobility of compressed air as a power allows a wide range of generators, or prime movers, but we can, in nearly all cases, rely upon having to adopt primarily, one of two sources of power, viz., water or heat.

Water, the first of these can, as we know, be used in many ways, each terminating finally at the mine, as compressed air ready for service. The initial water power may come from one or more sources situate either at the mines or many miles distant, and can be used either as a directly connected unit of power for the compression of air, or as a prime mover for some intermediary power.

British Columbia has been fortunately blessed with magnificent water power, more particularly in the Kootenays. In many cases these water powers are situated close to the mines ; in others, as at Rossland, they are several miles away.

Distances over which power can be economically transmitted by electricity are yearly becoming greater, until it seems that distance is no longer an obstacle, and it has become simply a question of capital investment to successfully transmit the power generated by water almost any distance.

Heat, the second great source of power for the generation of compressed air, has been successfully used as steam for many years, even in places which seemed to be utterly inaccessible either for the erection of the necessary machinery, or the securing of fuel after the machinery had been installed and made ready for operation. So accustomed have we become to surmounting difficulties of this kind, that we are apt to look with suspicion upon any suggestion to utilize distant water powers, preferring to resort to steam as being the power we best understand, and one which has been successfully installed and economically operated under very adverse circumstances.

British Columbia has been abundantly provided with fuel, in fact, we can say the supply of coal is practically unlimited. Enterprising capitalists, year after year, extend railways between the coal fields and the consumers, so that no producing or promising mining district has long to wait for an unlimited supply of this fuel. The mines at Rossland are exceptionally favored in this respect, all the leading mines having access to two lines of railways, and, thnough them, the coal fields of both British Columbia and the State of Washington.

Rossland is also favored by having the immense water power at Bonnington Falls, less than 40 miles distant, immediately available. The enterprise of Sir Charles Ross and associates in the West Kootenay Power and Light Co. have rendered this available for any service at each mine, as a competitor of the steam power, which mine managers would otherwise be compelled to adopt.

The question of the selection of power supply to be made by mine managers at Rossland is almost entirely removed from chance, and may be based on ascertained facts. Railways being at hand for the transportation of any kind of machinery, reasonably cheap fuel in quantities required is assured, and electric power for any size machinery or service is available. Therefore the problem simply resolves itself into "*Which of these powers will give the best service in operating the machinery used in connection with mining operations?*"

The same privilege applies to nearly every other mining district in Southern British Columbia; therefore, the writer feels that the results obtained in the air compressing plants at Rossland will be of special interest to the members of the British Columbia section of the Canadian Mining Institute, and mining engineers.

The steam and electric plants described below were modelled on the design and erected under the personal supervision of Mr. Bernard Macdonald, then general manager of the Le Roi and Nickel Plate mines, assisted by the writer. The steam plant was erected for the Le Roi Mining Company, Limited, and consists of the following, viz :

Boiler Plants.—Two 250 horse-power Heine safety water tube boilers, arranged to burn coal as fuel. These were intended to generate steam to run the air compressors, and were set so as to work, if desirable, in connection with the nine 125 horse-power steel shell return tubular boilers, designed to operate the hoisting and surface plants. These boilers are arranged to be interchangeable to either service. A general description of this plant will be found in Volume V., page 309, of the Journal of the Canadian Mining Institute.

During the test, the water-tube boilers were used at a guage pressure of 150 pounds per square inch, using Crows Nest coal as fuel, which cost, laid down in front of the boilers, $5.55 per ton of 2000 pounds.

Air Compressing Plant.—The steam driven plant consisted of two compound condensing Corliss valve engines, direct connected to two stage air cylinders, equipped with intermediate cooling devices, each machine having a rated capacity of 4000 cubic feet of free air per minute, or a combined capacity of 8000 cubic feet of free air per minute at sea level.

A more detailed description of these engines would be as follows :

	No. 1 Engine INCHES.	No. 2 Engine INCHES.
Diameter, high pressure steam cylinder..	22	22
" low " " " ..	36	36
" high " air " ..	22	22
" low " " " ..	36	38
Length of Stroke	48	48

Intercoolers, horizontal multitubular type ; condensers, independant jet.

The Electrically Driven Air Compressing Plant.—This plant was erected by the Rossland Great Western Mines, Limited, and was originally intended to be operated in connection with the steam plant previously descrtbed, the intention being to supply power from a central station to four mines, owned by different companies. This arrangement would have given each mine power at the lowest possible cost, and have ensured continuous operations by reason of the compressing plant being arranged in separate units. Each company would pay its share of operation, maintenance, of plant, *pro rata* to its consumption of air.

When it was found necessary to erect the third unit to the compressing plant, unforeseen difficulties presented themselves in the shape of shortage of water for condensing and cooling purposes. On examination, it was found that a satisfactory supply could not be secured without heavy capital expenditures for erection of flumes, etc., to convey the water to where it was required for use.

It was, however, found that a supply of water, barely sufficient for the intercoolers and waterjackets, was available about three-fourths of a mile distant from the steam plant. This supply was so located that it must either be pumped, or else the plant located at this distance away from the main steam plant. By conserving this water supply cooling and reusing it was decided a sufficient supply of water for the air cylinder jackets, and intercoolers could be secured.

The results obtained from the steam plant have proven so satisfactory, that it was considered questionable if any electric plant could be installed that could successfully complete with steam even when running non-condensing unless very favorable rates for power could be secured. After negotiations with the Power Company, it was decided to erect an electrically driven plant, a short description of which is as follows:

Electrical Equipment.—Three phase, S.K.C., synchronous motor, designed for 2200 volts, with a rated capacity of 660 Kilo Watts, equivalent to about 825 horse-power. The motor is provided with a separate starting motor, mounted on the main frame, exciter and Italian marble switch-board, on which all operating switches and instruments are mounted.

There is a 54 inch Frisbee clutch set intermediate between the driving pully and the motor. The motor is of a four bearing type, fitted with self-aligning and self-oiling sleeves. The entire machine is mounted upon a solid cast iron base set upon massive concrete foundations. The driving pulley is 60 inches in diameter, grooved for 22 1½ in. ropes, and runs at 270 revolutions per minute.

The three compressors were built by the Canadian Rand Drill Company, of Sherbrooke, Que., and are especially designed for constant service.

The electrical equipment is also entirely of Canadian manufacture, the entire apparatus being manufactured by the Royal Electric Company, of Montreal, who are the Canadian manufacturers of the S K.C. apparatus.

All tests were conducted under the personal supervision of the writer, and extreme care was taken to arrive at actual facts. Indicator diagrams were taken off both the steam and air cylinders every half-hour, and the results tabulated. Coal consumed was weighed, and all other supplies, such as waste, oil, etc., charged as used.

Readings were also taken and recorded by means of a delicately adjusted Kilo Watt metre, connected to the primary mains, of the amount of electric power used. The test extended over a period of thirty days, without interruption, both plants being run under exactly similar conditions as to air pressure.

Each of the plants tested being modern and representative of their respective types, gave an opportunity for a comparative test that rarely falls to the lot of an individual engineer under such favorable conditions, as to work being performed, and for this reason is the more valuable as data for basing calculations as to problems of power.

The average results of the thirty days' test is recorded in Tables I, II, III, IV, and V following:—

TABLE I.

Work Performed by Steam Plant.

Average indicated horse power at steam cylinders of the combined machines	730 h.p.
Free air compressed per minute from atmospheric pressure to 95 lbs. per square inch	5432 cubic ft.
Free air compressed per hour	325 920 "
Average horse-power required at steam cylinders to compress 100 cubic feet of air per minute, to Gauge pressure	13.4 h.p.
Pounds of coal consumed during test	1,038,000 lbs.
Pounds of coal consumed per day of 24 hours	36,400 "
Average pounds of coal consumed per horse-power per hour during test	1.9 "

TABLE II.

Work Performed by Electric Plant.

Average horse-power registered at switch-board	540 h.p.
Free air compressed per minute from atmospheric pressure to 95 pounds gauge pressure	3,319 cubic ft.
Free air compressed per hour	199,140 "
Average horse-power required at motor to compress 100 cubic feet of free air per minute to 95 lbs. gauge pressure	16.3 h.p.

TABLE III.

Cost of Operating Steam Plant.

Total cost of fuel consumed during test	$2,880 45	
" " wages for employees	710 00	
" " oils, waste, etc	147 30	
" " for 30 days, exclusive of maintenance and depreciation.		$3,737 75
Cost per horse-power per month for fuel	3 96	
" " " oil, etc	0 20	
" " " wages.	0 97	
		$5 15
Cost per horse-power per annum		$61 56
Cost for each 100,000 cubic feet of free air compressed		$1 56
Cost per drill shift		$1 25

NOTE:—80,000 cubic feet taken as the average consumption per shift of one 3¼" drill

TABLE IV.

Cost of Operating Electric Plant.

Cost of current for thirty days	$1,744 26	
" employees' wages	270 00	
" oils, waste, etc	73 00	
Total cost for 30 days, exclusive of maintenance and depreciation		$2,087 86
Average cost per horse-power per month		$3 87
" " " annum		$46 44
Cost for each 100,000 cubic feet of air compressed		$1 46
Cost per drill shift		$1 17

NOTE :—80,000 cubic feet taken as the average consumption per shift per one 3¼" drill.

TABLE V.

Showing Comparative Results between the Two Types of Compressors, based on each 100,000 cubic feet of air compressed from Atmospheric Pressure to 95 pounds Receiver Pressure.

Cost for each 100,000 cubic feet of free air compressed by steam plant (see Table III)	$1 56
Cost for each 100,000 cubic feet of free air compressed by electric plant (see Table IV)	$1 46
Result, saving by electricity over steam	6.4 per cent.

The saving shown in Table V would be affected adversely if the electric plant was operated singly and the entire air compressed was not used. For the reason that electrically driven compressors must be operated at constant speed, and loss of air at safety valve would be considerably increased over the same loss at steam plant, which could be run at the speed required to compress the amount of air actually required. This loss would, however, be slightly off-set by the increased cost per horsepower by working the steam compressors on underload.

I wish to draw special attention to the noteworthy result obtained from the system of intercooling used on the compressors tested.

In Table I it is shown that the steam plant required 13·4 horsepower to compress 100 cubic feet of air to 95 pounds gauge pressure per minute. The best power factor recorded that has come under the writer's notice, for doing the same amount of work by a two stage compressor, is 14·5 horse-power, which shows a saving of 8 per cent. resulting from the use of specially designed intercoolers, for which the manufacturers are entitled to receive the credit.

How this result is obtained can be best understood by reproducing the average of a number of tests made on the efficiency of the intercooler during the progress of the power test. The results of these tests are shown in Table VI.

TABLE VI.

Temperature of cooling water at inlet of intercooler	42°F.
Temperature of cooling water at outlet of intercooler......	50°F.
Rise in temperature of cooling water while passing through intercooler..	8°F.
Temperature of air at outlet of low pressure cylinder and before passing through intercooler.................	196°F.
Temperature of air at inlet of high pressure cylinder, after passing through intercooler........................	54°F.
Reduction in temperature of air after passing through intercooler..	142°F.

In conclusion, permit me to state that this paper has not been prepared with the idea of recording the performance of these two plants, except, in so far as comparisons can be drawn between the relative efficiency of the two systems, so that engineers, knowing local conditions, can have some record of actual performance before them.

Mineral Resources of Vancouver Island.

By W. M. Brewer, M.E., Victoria, B.C.

The mineral resources of Vancouver Island comprise coal, gold ores, copper gold ores, a little galena, and magnetite. Although the first discovery in coal was made on the east coast of the island as early as 1835, no systematic work of prospecting or developing was commenced until 1849, when the Hudson's Bay Company brought a party of coal miners from Scotland and commenced work at Suquash, a point on the coast near Port McNeil and semi-distant between Alert Bay Harbour and Hardy Bay. About 1852, the Company abandoned work at this point and commenced mining for coal on the present site of the City of Nanaimo. In 1862, that portion of the coal field together with the coal on Newcastle and other nearby islands was sold to the New Vancouver Coal Company. It was about this time that the late Honourable Robert Dunsmuir, who had been in the employ of the Hudson's Bay Company during their operations, resigned from their employ and started to prospect for coal fields on his own account. The first locations he made were the Harewood mines, which he sold to an English syndicate and which are at present being worked by the New Vancouver Coal Company. About 1869 or '70 Mr. Dunsmuir discovered the Wellington seam on the Nanaimo River and secured from the Imperial Government—previous to the entry of British Columbia into the Confederation—the tract of coal-bearing land which laid the foundation to the large fortune which that gentleman acquired before his death. The shipment of this coal to California ports is directly responsible for the partnership which was entered into later between the late Mr. Dunsmuir and Messrs. Huntington, Stanford, Crocker and Hopkins, the *Big Four* of the Southern Pacific, which partnership resulted in the building and equipping of the Esquimalt and Nanaimo Railway, and opening of the Northfield, Extension, and Union Collieries. The foregoing is a brief history of the beginning of the coal mining industry on Vancouver Island.

The history of metalliferous mining commenced with the discovery of placer gold on the Leech and Sooke Rivers about 25 miles from Victoria in 1860, and during the big rush to the Cariboo Placer Mines. These discoveries were succeeded later by others on the China and Granite Creeks which empty into Alberni Canal as well as on Bear River, which empties into Bedwell Sound, on the west coast of Vancouver Island. It was not, though, until 1893 or '94 that any further attention was given to prospecting for other than placer gold and it was really not until the commencement of the Klondyke excitement that any really serious efforts were made in prospecting even the coast-line on the western side of the island. Since then gold-bearing quartz, partially free-milling, copper ores and iron ores have been discovered on the west coast occuring in zones, having a general trend to the north-west, as well as copper-gold ores in the south-eastern portion of the island on Mounts Mallahat, Skerrit, Sicker and Brenton.

Geology.—Roughly speaking the geological formation of Vancouver Island can be divided into three separate classes of rocks, viz :—Cretaceous sandstones, and shales in which occur the coal measures, a belt of semi-crystalline slates, and Dawson's Vancouver series, which according to his classification embrace the igneous and metamorphic rocks together with the crystalline limestones. The latter is considered by the same authority as probably belonging to the carboniferous period.

If a map of the island is consulted, the areas covered by these different formations are found to be as follows :—

Around Victoria and the extreme south end of the island, rocks of the Vancouver series, north from these and occupying a belt extending from Saanish Inlet across the island to the Gordon River and San Juan Harbour occurs the belt of semi-crystalline slates and schists in which are found a considerable quantity of graphitic slates. Northerly from this and extending along the east coast are the cretaceous coal measures with occasional breaks occupied by rocks of the Vancouver series. West from the coal measures, the island, so far as is known, is made up of rocks of the Vancouver series except a narrow fringe of sandstones, shales and conglomerates, possibly belonging to the Tertiary period, along portions of the shore line of the west coast.

No thorough geological survey having ever been made of the island it is very difficult to particularize and give other than a rough and approximate idea of the general geological features. Several geologists, mining engineers and prospectors, as well as the writer, have made notes on various sections, but as all of these are separated from one another by miles of intervening rock, of which absolutely nothing is known, the conclusions drawn are necessarily only vague. For instance, the Sooke mountain range is made up of a semi-crystalline slate and schists with stringers of quartz, which often widen out into lenses of some 3 or 4 feet in width and 40 to 50 feet in length interfoliated conformably with the general strike and dip of the formation, which has been traversed by several streams, among them the Leech, Jordan, Gordon and San Juan rivers. Consequently the writer has assumed that this zone or belt of formation extends across the island, although the middle portion of it, from the head waters of the Leech River on the eastern side to the head waters of the San Juan on the western side has never been actually visited by him.

As a matter of fact there is a very large portion of Vancouver Island even to-day which has never been explored by white men, and it is less likely to have been by the Indians because all the tribes occupy rancheries or reservations on the coast lines, devote their time to fishing and sealing, as they very much prefer travelling by canoe or boat to climbing mountains and pushing their way through the sallal or other underbrush with packs on their backs. For this reason but little information can be gathered from the aborigines, who, as a rule, in most of the western country have explored extensively previous to the invasion by white men.

There is a certain regularity about the mineral-bearing zones on the west coast; for instance, the zone in which non-cupreous magnetite occurs is situated nearer to the coast line than the zone carrying copper ores; while the zone in which gold-bearing quartz is found lies to the north-east from that in which copper ores are found.

The geological and mineralogical features of Vancouver Island, so far as the observations of the writer go, present many very interesting, complicated and to a great extent, unique characteristics.

While the zones of country rock have some regularity as regards strike and dip, yet the results from eruptive action have been such that extensive and innumerable faults are encountered which add to the complications in prosecuting development work. There are no leads in the general acceptation of the word. The ore bodies are composed principally of lenses occurring either at the contact of igneous dykes and limestone, or else in fissures in the igneous rocks, or as lenses in schistose rocks. The characteristic fissure veins of Colorado are, so far as the writer's observations have extended, entirely wanting on the island. While it is true that you can in many instances follow an outcrop from point to point for distances varying from 200 to 1,000 feet, yet development demonstrates that the so called lead is made up of lenses lying *en echelon* to each other and usually having a pitch in a different direction to the dip. In following such ore bodies down it has been found that they possess similar characteristics in a vertical direction to those in a horizontal direction. Consequently, before the engineer is thoroughly competent to prosecute development work on the island, he should make a very close study of the geology and of the results from development work on neighbouring properties, otherwise he is liable to make mistakes which he will regret.

One of the features peculiar to Vancouver Island is the heavy outcroppings of hornblende which contains so great a percentage of iron that the surface has the same rusty ochreous appearance as is found in the regular gossan outcroppings, but on being broken into it is found that this apparent iron capping is only a thin scale underlaid by hornblende crystals, many of which are undergoing the evolution which alters the hornblende into asbestos, and closely associated with which are crystals of iron pyrites. Another is, that there is practically no oxidized zone, but the unaltered sulphides of copper occur immediately under the surface ; in fact the writer has found crystals of copper pyrite which showed by assay as high as 24 per cent. copper within a foot or two of the surface and enclosed in a mass of magnetite. Garnet rock and epidote are usually found associated with the magnetite and copper deposits on the island, as gangue material and forming ledge matter.

The question of origin of the ore deposits is one which will interest geologists and engineers very much. Apparently the magnetite is the resultant from the basic igneous rocks and illustrates Posepny's theory, but the question has been propounded as to whether these rocks are sufficiently basic and whether or not the deposition of the magnetite is due to some other cause.

Posepny, in his treatise on the " Genesis of Ore Deposits," has the following paragraph, viz.: " As to the eruptive rocks we do not know what they once were, as we study them only from the moment of cooling. But we observe at once that iron—a metal widely distributed in all deposits and in nature—generally occurs primitive in these rocks in the form of magnetite, a mineral of striking metallic appearance."

Felsite is found very frequently in contact with the crystalline limestone and the igneous rocks. This felsite apparently occurs in dikes as intrusions, and a close examination of the formation where such dikes occur suggests the probability of movements at different periods and the possibility that the felsite intrusions belong to an older period than the intrusion of the other igneous rocks, and also that the ore bodies are more closely associated and have been more thoroughly influenced by the intrusions of the felsite than of the other igneous rocks in locations where the ore occurs as contact deposits, but where the ore fills fissures in the diorite, or diabase, the winter has noticed the absence of felsite and also the fact that the magnetite with the associated chalcopyrite does not apparently maintain continuity to any great depth, but that both classes of ore give out simultaneously. Evidently the chalcopyrite has been deposited by the infiltration of copper charged waters through crevices and porous places in the magnetite, and it is very questionable, in the opinion of the writer, whether these fissure ore bodies will possess any great value as compared with the contact bodies and the lenses in the schist formation. In the two latter occurrences but little, if any, magnetite is noticeable associated with the chalcopyrite.

One peculiar characteristic which is generally noticeable with regard to the ore bodies which fill fissures in the igneous rocks is that there is only one well defined wall instead of both walls being well defined as in the general run of fissure veins in Colorado, for instance. As a matter of fact the fissures in the igneous rocks on Vancouver Island appear to approach more nearly to the cleavage planes of faults in which the work of replacement has been progressing until ore bodies of variable width and of lenticular structure have been deposited. The change from solid ore to barren country rock has been gradual. These conditions are noticeable in very many of the ore bodies occupying these so called fissures. Often, too, when the ore has given out entirely the one wall remains perfectly good with a coating of calcite varying in thickness from several inches down to a knife-blade as a parting between the wall and the country rock. Narrow seams of calcite will often be found entending into the country rock on both sides of the wall and filling fractures. These fractures, and indeed the fissures in which ore bodies are found, in the judgment of the writer, are merely contraction joints caused by the cooling of the igneous rocks from a molten condition.

Economic Features.—Those portions of the island which are actually productive at the present time naturally possess a greater interest than the non-productive, and it is these which the writer will discuss in the present paper rather than the sections in which, although mineral has been discovered, locations made and prospecting work done, are still in a non-productive stage.

Starting from the south end of the island the first productive district is Skerrit Mountain, where in 1897 was made one of the first locations of copper-gold ore recorded on the island. The ore-body has a maximum width of about 4 feet and occurs in shoots. The one on which most development has been done is 90 feet in length. The ore mined from it to a depth of about 60 feet was shipped to the Tacoma smelter during the year 1900 and yielded from 12 to 15 per cent. of copper about 7 ounces of silver, and a dollar in gold to the ton. This ore body occurs in a metamorphosed slate, in which occur dykes of eruptive rock and the ore body apparently fills a space between these two varieties of rock, in which also has been deposited a considerable thickness of quartz; so that, frequently, the quartz ledge-matter is found unaccompanied by ore, but at other times the solid ore occupies the entire space. A series of faults have been exposed during the progress of development work, through which the ore body is thrown several feet horizontally; consequently, to a casual observer there are apparently three or four distinct leads, when, as a matter of fact, the conditions indicate the system of faulting as described by the writer.

The next productive portion of the island is that known as the Mount Sicker District, in which are located the "Lenora," "Tyee,"and other mineral claims. Of these, the Lenora has shipped in all about 35,000 tons or ore, and in the Tyee the management report 60,000 tons blocked out. The character of this ore is chalcopyrite in a baryta, garnet, quartz and iron pyrite gangue. The grade averages about $5.00 per ton in gold; 5 per cent. (dry) in copper, and variable silver values.

These ore bodies are lenticular in structure and occur interfoliated between schists, with their lines of strike conformable to the schistosity of the rock, but apparently not conformable to the original bedding-planes. The schistosity has been caused apparently through shearing movements, resulting from the intrusion of dykes and convulsions of the earth's crust. The schistose rock is so altered as to make a microscopical examination by experts necessary before it can be properly classified; the igneous dykes in some instance have porphyritic structure, in others resemble diabase. The occurrences of ore are, so far as the writer's observations have gone, confined to the sheared zone, and where the rocks are massive, or even at the contact of the massive dykes and the schistose rock, ore bodies do not occur. This condition, though, may not be a general rule, but may prevail only at such points as have been examined by the writer.

During the early development stages of these properties, the writer was severely taken to task for expressing the opinion that the ore bodies were lenticular in structure instead of occupying a continuous lead and maintaining unbroken continuity to some undetermined great depth. But the development work done up to the present time has demontrated clearly that the writer at that time described the structure of the ore bodies accurately as such has been since determined by actual work.

The sheared zone in this district is of, as yet, undetermined extent, longitudinally it maintains continuity through Mt. Sicker, across the Chemainus river, and westerly throught Mt. Brenton. The trend, or line of strike, of this zone is to the west, while the general trend of the country rock of the island is north-westerly. It is quite possible that this zone of schistose rocks has merely local limitations, because the Alberni Canal traverses the westerly portion of the island for some 28 miles, and if these schistose rocks maintained continuity in a westerly direction, this canal ought to crosscut the formation; but, if such be the case, the fact has been unobserved by the writer, nowithstanding that he has made several expenditions along both shores of the canal—which, however, does crosscut a copper-bearing zone, the rocks composing which, though, suggest a different geological formation. The Mt. Sicker formation also occurs on the north side of Maple Bay, on the east coast of the island, but in that locality the belt of schistose rocks is apparently of very much less extent in width than on Mts. Sicker and Brenton.

Travelling northerly from the Mt. Sicker district, the coal measures are met within a comparatively short distance, and so far as the extreme eartern coast of the island is concerned the crystalline rock do not again appear, except in limited areas around Nanoose Bay and a strip along the shore line of Discovery Passage and Johnstone Strait. It is along that portion of the Eastern Coast from Oyster Harbor—a short distance north from Mt. Brenton—to Comox Harbour, a distance of about 75 miles, that the productive coal mines are located. From these have been exported for several years an average of about a million tons of coal per year; in fact the chief market for the total output of these mines has been California. These are collieries located at Extension, about 10 miles west from Oyster Harbour; at Alexandria, about 10 miles north of the Harbonr; at Nanaimo and Harewood, 15 miles north from the Harbour; at Wellington, about 6 miles north-west of

Nanaimo, and at Union, about 11 miles inland from Comox Harbour. All of these collieries, with the exception of the original Wellington Colliery, are producing bituminous coal to-day, and a good quality of coke is being made at Comox Harbour. Railway connection between the collieries and salt water have been established for several years past. The coal industry alone has built up the flourishing towns of Nanaimo, on Nanaimo Harbour, Ladysmith, on Oyster Harbour, and Union, about 12 miles from Comox Harbour, besides being the cause for the building of entensive wharves, bunkers and coal washers at the harbours. Coke is only manufactured at Comox, where a plant of 200 bee-hive ovens has been constructed. The coke manufactured at that point, although carrying a somewhat higher percentage of ash than the best Pennsylvania coke or the Crow's Nest Pass coke, has always found a ready market in the coast smelters and previous to the develepment of the Crow's Nest Pass coal field was used by the smelters in the interior of British Columbia.

In the southern portion of this coal field there are two workable seams of coal designated as the Wellington and Douglas; of these the Douglas is the upper seam and is mined at the Nanaimo and Alexandria collieries, while the lower is only mined at the old Wellington and Extension collieries, in which fields apparently the upper seam has been carried off by erosion.

Much faulting has occurred through this portion of the island, which of course causes many complications in the workings. For instance, a bore-hole on the Harewood property, which adjoins the Nanaimo Colliery property, exposed a workable seam of coal, but a shaft sunk about 200 feet from the bore-hole failed to intersect the seam at the depth estimated, and later investigations prove that a fault has occurred in the space between the shaft and bore-hole which was not apparent on the surface, and the downthrow had been 80 feet.

The total area of the productive territory of the coal fields on the east coast of Vancouver Island cannot be estimated because no accurate detailed geological survey has been made. With the exception of the Wellington Colliery proper, which was the private property of the late

Honourable Robert Dunsmuir and at which work was suspended some months back, the acreage owned by the New Vancouver Coal Mining and Land Co. and a few small holdings, the entire field is included in the land grant of the Esquimalt and Nanaimo Railway Company. So far as the east coast of the island is concerned there are no other productive mineral-bearing properties, and in fact but comparatively little is known of the interior of the island to the north-west from the Mt. Sicker district, and south-easterly from Quatsino Sound, except around the head of the Alberni Canal, which body of water penetrates to within about 25 miles of the east coast with its entrance in Barclay Sound on the west coast. Quatsino Sound penetrates from the west coast to within about 10 miles of the east coast of the island and near the north-west end.

It was on the China and Granite Creeks which empty into Alberni Canal on the eastern side, where placer gold was discovered in the '80's, but the neighbourhood was not prospected for lode mines until since 1894.

Gold-bearing quartz bodies, occurring as long lenses, with their lines of strike conformable to the trend of the country rock, have been mined on Mineral Hill, near the head of China Creek, and in the mountains near the head of Granite Creek, but at the present time no operations are being conducted. Some of this quartz carried extremely high gold values at, and near the surface, and was partially free milling, several tons of ore having been treated from the Consolidated Alberni group of claims on Mineral Hill and the 3 W's group near the head of Granite Creek. At the former of these properties the country rock is a schist, but at the latter the ore occurs in granite. The schists of China Creek contain considerable hornblende and very probably are really altered granite. Further down the canal, which crosscuts the country, there is quite a marked change in the country rock, and a wide zone of crystalline limestone, in which diorite, diabase and some felsite as intrusive dykes occur. In this have been discovered a large number of prospects carrying copper ores, usually chalcopyrite, associated with pyrrhotite, some of which have been productive, and on one at least some 5,000 feet of development work have been performed. This zone apparently extends to the north-west for quite a considerable distance, because the streams which empty into the inlets further to the north-west crosscut similar formation, in which a great many prospects carrying the same character of ore—but associated with magnetite, as a rule, instead of pyrrhotite—have been located. A prominent feature with regard to the ore bodies in this zone is the phenomenal appearance of the outcroppings, both as to extent and grade, while another prominent feature is the complicated geology as demonstrated by the mine workings. Apparently this particular zone disappears under the ocean in the vicinity of Nootka Sound.

In the mountains near the shore line of Sydney Inlet occurs a mineral-bearing zone which, judging from the character of the country rock, belongs to or is an extension of the same zone as has just been described, but in which the character of the ores differ, to this extent that extensive bodies of high-grade bornite occur, with which is associated at the deeper levels chalcopyrite. Although a very considerable amount of development work has been performed upon, at least, two groups, the Anaconda and Black Prince, and it is reported that considerable ore has been accumulated, yet because of lack of tramways to connect the mine workings from the shore no shipments have been made. Between Sydney Inlet and Quatsino Sound but comparatively little prospecting has been done. The country is very difficult to travel in; the mountain ranges are higher than is usually the case from Sydney Inlet to the south-east, the growth of timber is very heavy and the sallal and other underbrush extremely dense.

The most northerly productive section of the island is along the shore line of the main Quatsino Sound and its arms, where copper ores occur in enormous outcroppings and from which shipments, carrying satisfactory values, have been made to the smelters. These occurences of ore are found at or near the contacts of crystalline limestone with felsite or other igneous dykes. Although the country rock belongs to Dr. Dawson's Vancouver series, yet the particular zone in which the mineral occurs, in the opinion of the writer, does not bear any relationship to that crosscut by the Alberni Canal, but appears rather to belong to another zone which crosses from the eastern side of the island. However, this is merely offered as a suggestion, as neither the writer, nor to his knowledge, anyone else has exploited to ascertain the extent of the zone towards the south-east or east. During the present year considerable activity has been shown in the development of this section and shipments have been made to the Tacoma and Crofton smelters. At the present time an aerial tramway is being constructed to facilitate shipment from the mines to the coast.

The non-cupreous magnetite deposits which have been before referred to in this paper, as occupying a zone along the west coast of the island, have during the past two or three years received a great deal of attention from syndicates which acquired bonds on all the available workable deposits possible, and have been developing such with a view of shipping the ore to the Irondale furnace in the State of Washington for manufacture into pig-iron.

So far as the writer's observations have gone this zone is apparently entirely distinct, so far as the mineral deposits are concerned, from any other on the island; but so far as the country rock is concerned, practically the same geological conditions exist as in the copper-bearing zone already described. The known deposits of magnetite occur on the Gordon River, which empties into the San Juan Harbour, about 70 miles west from Victoria; Serita River, which empties into Barclay Sound, near the entrance to Alberni Canal; Tzartoos or Copper Island, situated in Barclay Sound; and on Sechart Peninsula, a promontory north-westerly from Copper Island, and also in Barclay Sound. Whether the same zone extends farther to the north-west has not, to the writer's knowledge, been yet determined, but deposits of iron ore are reported as occurring in the mountains near the shore line of Nootka Sound.

From the foregoing paper some idea can be gleaned as to the possibilities of the mineral resources of Vancouver Island when thoroughly exploited and developed. The writer has only attempted to go into the subject in a crude manner and not in the finished, comprehensive style which the subject really merits.

Safety Lamps and Colliery Explosions.

(Discussion of the paper by Mr. James Ashworth.)

By MR. WILLIAM BLAKEMORE, Nelson, B.C.

There can be no doubt that the subject of safety lamps is of the greatest importance in connection with coal mining; possibly of greater importance than the regulation of blasting, with which it divides the attention and interest of mining men.

The result of thirty years' experience, during which time I have tested every safety lamp which has been put on the market, leads me to the conclusion that the best result which can be obtained is only a certain percentage of safety, and of the lamps which approximate the closest to this standard I would specify the improved Hepplewhite Gray for testing processes, and the Mueseler. The former will, in my judgment, detect the presence of a smaller percentage of fire damp in the air than any other lamp, certainly than any other oil and wick lamp; and as long as this is the method of illumination I do not see how it is possible to construct a lamp mechanically more perfect than this. The fact that the only inlet is by the way of the vertical tubes which admit air and gas at the top of the lamp and deliver them direct to the flame seems to me to give the maximum efficiency in this particular. I commenced to use the Hepplewhite-Gray for testing purposes when it was first invented, and have continued its use ever since; the only objection which has developed with experience is its liability to become extinguished by a sudden jerk, but this is a defect which it has in common with the best lamps, and can hardly be considered an element of danger. I have always found the finger-holes and slides upon the tubes of great value for testing purposes, and the proper manipulation of these renders the lamp as sensitive as can reasonably be expected for practical purposes.

With reference to the Mueseler, this lamp, when bonnetted, is as efficient and safe as any lamp with which I am acquainted for ordinary working purposes, and if used in combination with the more delicate lamp above referred to, furnishes a combination which I think meets the requirements of the case.

I am aware that the Wolf lamp is largely used in Pennsylvania and is growing in favor; it is a good lamp, but possesses one drawback which I consider fatal to all lamps of this class, viz., that it burns benzoline oil. The presence of a volatile oil in connection with a safety lamp is an added source of danger and will not long be tolerated in mines. I agree with Mr. Ashworth's remarks that the safety of a lamp is dependent, not upon ordinary conditions prevalent in a mine, but upon its ability to resist exceptional conditions which may be instanteously produced, and this point must never be lost sight of, because the exceptionally dangerous condition may be produced at any moment and without the slightest warning. This is why all such lamps as the Clanny must be resolutely condemned, because although they may be perfectly safe under the normal conditions prevailing in a mine they become unsafe and highly dangerous in the presence of a sudden outburst of gas, an acceleration in the velocity of the air current, or the presence of a large quantity of coal dust.

As reference has been made in Mr. Ashworth's paper to the Fernie explosion I may be permitted to say that in my judgment the preponderance of the evidence adduced at the inquest pointed to the Clanny lamp as the undoubted origin of the explosion. This lamp was being used in immediate proximity to a feeder of gas, and at a point where, according to the evidence of the chief mine superintendent, the velocity of the air current was ten feet a second. After the explosion a lamp was found within a few feet of this feeder completely shattered, and although of course there can be no direct evidence on the point, the conjunction of all the elements necessary to produce an explosion rendered the matter one of easy natural deduction, especially as it was proven that the air was heavily charged with dry coal dust at this point. The behaviour of different lamps in a mixture of coal dust and air will undoubtedly form a subject for careful investigation, as hitherto the experiments made with coal dust have been more or less confined to testing its behaviour in the face of explosives; it may, however, be interesting to mention that in connection with the Fernie explosion one of the most experienced miners, Angus Ferguson, stated that he had frequently, when carrying a bonnetted Clanny in the works along the main haulage road where there was heavy coal dust but no gas, found the coal dust accumulate upon the lamp, and on shaking it slightly to get rid of the same a dull red flame would fill the lamp. The next question to solve would be—at what point this flame would connect with the outside of the lamp, and this is undoubtedly one of the problems of the times in connection with dry and dusty mines, because the conditions referred to prevail in so many.

My concluding remark must be an endorsation of Prof. Golloway's observation in his report on the explosion at the Universal Colliery, viz.: that recent occurrences lead to the irresistible conclusion that coal dust is relatively more dangerous in a mine than fire damp.

By MR. W. D. L. HARDIE, Lethbridge, Alta.

During many years practical experience in bituminous coal mines, both in America and Europe, I have paid much attention to modes of working and the dangerous elements that enter into the practice of coal mining. I have found in nearly all, if not every one of the superior coking coals, which lie comparitively flat and not much faulted, whether marsh gas be present or not, that the dust has a more or less marked "greasy feel," indicating that in addition to the carbon there must be some of the heavy hydro-carbons of the paraffin series present in the volatile matter. When such a seam gives off fire-damp the damp is very likely to be "sharp," indicating that hydrogen, as well as the heavy hydro-carbons, is likely a constituent of the fire-damp.

Under these conditions, which, I think, from personal examination, hold good at Fernie, B.C., the inflammable point of the explosive gas given off is very much lower than that of ordinary fire-damp. Under such conditions the explosive point is reached with a less percentage of gas, and of course the quantity of the gas to give the maximum explosive force will also be much less in the explosive mixture. If the Fernie coal dust carries a small percentage of heavy hydro-carbons or free hydrogen, it can be readily imagined how easily the dust could be raised to an incandescent heat and the hydro-carbons distilled in quantities large enough to cause an explosion of any magnitude, if plenty of coal dust has been deposited in the mine, having its initial cause in the ignition of a small quantity of gas, or from many other causes, even if explosive gases were not present in such quantities as could be detected with the ordinary, or even improved safety lamps. By improved safety lamp I do not mean those specially designed for delicate work.

Under these circumstances it is of the utmost importance that the smallest percentage of gas should be detected, but it is just of as much importance that all the other dangers should be known and cared for. For years I have used the Ashworth-Hepplewhite-Gray lamp in several forms, including Clow's hydrogen flame, the Pieter lamp without and with Garforth's rubber ball, and Shaw's gas-testing machine, with singularly good results. To the use of these appliances and a fairly good knowledge of gases, and a good grasp of " the hydro-carbon in coal dust " theory I attribute my success, in over twenty years practical experience, in avoiding accidents in some of the most gaseous, dry, and dusty mines on this continent. In one colliery, which exploded before I took charge, I had the greatest difficulty for a long time in instilling into the officials' minds the great necessity of getting a complete knowledge of the " hydro-carbon in coal dust " theory, but was successful in avoiding accidents while I remained there. Since then there have been several minor explosions, and one very large one, killing over 100 men, dating not more than six months back.

I do not think that the coal dust theory should ever be lost sight of in mines where the volatile constituents form any considerable percentage of the analyses. In anthracite mining the problem is not so difficult; in such seams the danger is mostly, if not altogether, marsh-gas. The South Wilkes-Barre Colliery, Pennsylvania, U.S.A., is perhaps the most fiery colliery in the United States, as much as three and four per cent. of fire-damp being detected almost constantly in the fan drift by the Shaw gas tester, but there the problem is not a particularly difficult one, because there is no dangerous coal dust, no element not well understood.

By far the largest number of explosions on the American continent take place in dry and dusty bituminous coal mines, some of which gave off fire-damp, while in others that have exploded never a sign of fire-damp has been seen on a safety lamp, yet the lives lost in each of these mines count up in hundreds. In many of them I am sceptical as to whether there was any gas given off. I trudged round the East mine of the South-west Virginia Improvement Co., Pocahontas, Va., and worked at the coal for over six months after the explosion there, in the vain hope that I would be able to find something that would indicate that there was some marsh-gas present, but I never saw it. In the presence of several officials of the company and Andrew Roy, then the chief mine inspector for Ohio, I fired a heavy shot in a wide room where the coal was mined at least five feet deep. After such a shot a long tongue of red flame invariably shot out from twenty to thirty feet, and if the coal came down, flame at white heat played around behind the coal, in many cases dying out gradually, the last small flame presenting the blue cap. This only supported my idea of the distillation of the hydro-carbons in the coal dust. I have seen the same phenomena in most seams of a good coking quality. If marsh-gas be present, forming a mechanical mixture with air, the phenomena will be intensified.

From the foregoing remarks it will be seen that I am not one of those who believe that it is necessary to have a percentage of marsh-gas present before we can have a "coal dust explosion." But woe will surely betide the manager who has both coal dust and gas present if he does not carefully take care of both, with the most advanced knowledge of the day. I would not think of being in charge of any dry and dusty mine without endeavouring to detect explosive gas with the most improved safety lamp or other detector known to the mining fraternity, even if in my mind I thought there was no possibility of gas being present: one can never tell.

Even if it be admitted that gas must be present before a "coal dust explosion" can take place, "the enquiry into the Seaham disaster in 1880 showed that the presence of two and one-half per cent. of fire-damp in a dry and dusty mine created an atmosphere which would in the presence of a blown-out shot, over-powdered shot, or a badly placed shot, bring about a fearful disaster." There are not so very many who can detect even three per cent. of fire-damp with the ordinary safety lamp. Of course there are lots who think they can, but can they?

Where gas, coal dust, or both are present in a mine it is the duty of the manager to know all that is knowable about the dangers connected with the same so that he may do the best to protect the lives of the men entrusted to his guidance and protect the company's valuable property from damage or destruction.

It is a well known fact that increased temperature reduces the temperature of ignition and that a low barometer reduces the violence of a gas explosion, but there are factors of small moment where coal dust is one of the elements when looking into the mechanical effect of an explosion; but in the case of gas detection, increase in temperature and reduction of temperature (low barometer) may be of considerable importance.

Another point, I will mention in passing, is that the effect of coal dust on the flame of a testing lamp is not generally given the consideration it should have by the fire bosses and other officials in dry and dusty mines, on this continent. Here is another opportunity for the distillation of explosive gases on which I have laid so much stress. Coal dust in contact with the flame of a testing lamp is a condition that might well be made the subject of a scientific paper. Coal dust in the meshes of the gauze of an ordinary safety lamp becomes incandescent almost instantly and passes the flame to the mixture outside of the lamp.

Mr. Ashworth's lamp is simply an improvement on the Gray lamp, which had the good fortune to be highly recommended by the Royal Commission, and there is no doubt but it is a good lamp; however, it has not passed through its course without considerable objection being raised to it by many able mining engineers and mine managers in Great Britain. As recently as the years 1892-3 Mr. Stokes and Messrs. Ashworth and Clowes had considerable controversy as to the relative merits of the Stokes and the Ashworth lamps. From the discussion that followed, I gathered that both lamps had about an equal number of supporters, but all seemed to be unanimously of the opinion that both lamps were good and capable of detecting equally small percentages of gas, but the Stokes lamp had the advantage of using alcohol instead of hydrogen gas used in the Ashworth lamp then under discussion. Both lamps use oil for testing for over 2½ per cent. of gas.

Mr. Ashworth in his paper does not discuss the percentage of gas his lamp will detect, but satisfied himself with saying that "it will detect more readily and with greater certainty the presence of the blue cap than any Davy lamp which was ever made." This is definite, but not very informative, and presupposes a knowledge not had by all who will read his paper.

Mr. Ashworth's paper is a valuable one; if it will induce the mine managers and mining engineers in Canada and the United States to give safety lamps and other subjects in coal mining the thought they deserve, by giving the chase for cheap coal just a little less attention, it shall have served a good purpose.

MR. JAMES ASHWORTH, Chaddesden, England.

I agree with most of the conclusions arrived at by Mr. Blakemore, of Nelson, and Mr. Hardie, of Lethbridge.

It is quite possible that the explosion at Fernie was initiated by the failure of a Clanny lamp, but it is *impossible* for an explosion within any safety lamp to "shatter" the lamp, and it is also impossible to even open the seam of a gauze by an explosion within the lamp if it has been made with any ordinary care. A lamp might fail and then be broken by a fall of roof, but even this is not of one of the likeliest of possibilities, because the point where an explosion originates is the one from which the destructive forces radiate, and is therefore the centre of compression, and no force passes over the lamp—it may in fact be said to be immersed in the force. Sometimes there is evidence of the "back lash" of the explosion when the vacuum resulting from condensation comes into play, and under this condition a lamp in a main road might be knocked about, but it would show that the force which smashed it was operating from the outside and not from the inside.

There cannot be a doubt in the minds of people who have seen fine coal dust ignite inside a safety lamp, that it will do so more readily than firedamp, and also that as the particles are so small as to pass through the mesh of the gauze, flame from the ignited or incandescent coal dust may be produced outside the gauze and be the cause of a disaster, even without an explosion within the lamp.

Both Mr. Blakemore and Mr. Hardie recognise this risk as a valid and dangerous one, and about which we require more information.

Mr. Blakemore considers the use of benzolene in safety lamps as a fatal drawback, but in this respect I must differ with him entirely. Benzolene or, as it is sometimes called in England, colzalene (also benzine in translations from the German) has been and is still very extensively used as an illuminant, and judging from a long experience with it, I can say that it may be applied with perfect safety in a safety lamp, if the lamp is properly constructed to burn a volatile oil or spirit. Lamps thus supplied are not quite so economical in the cost of lighting as when using paraffin, or oil mixtures, but it is cleaner, and gives a good illumination with the minimum of attention. The greatest danger arising from its use is in the filling of the lamps, and they ought not to be filled to a greater degree than the sponge or cotton wool will absorb. Then the lamp itself should be of the best construction, and in my paper I call attention to two distinct risks which are attached to the Wolf class of lamp, viz.: 1st, the double air admission, that is from below the flame as well as from above the flame,—this construction was proved by the English Mines Accidents Commission of 1886 to be a far from safe mode of feeding the flame with air, and confirmed the experiments previously made by M. Marsaut; 2ndly, the igniting apparatus, which if brought into use whilst the lamp is full of gas mixture will originate an explosion and propel the flame straight through the gauzes. Therefore, I say that benzolene may be a perfectly safe and an excellent illuminant, if applied under a safe cover.

For gas testing purposes, and if applied in lamps of the Gray type, it is one of the best and handiest means of testing for lower percentages than can possibly be detected by an oil flame. I enclose you a photo of one of my Gray oil vessels constructed to use benzolene and fitted with a Wolf igniter, for the use of firemen and examiners, Fig. 1.

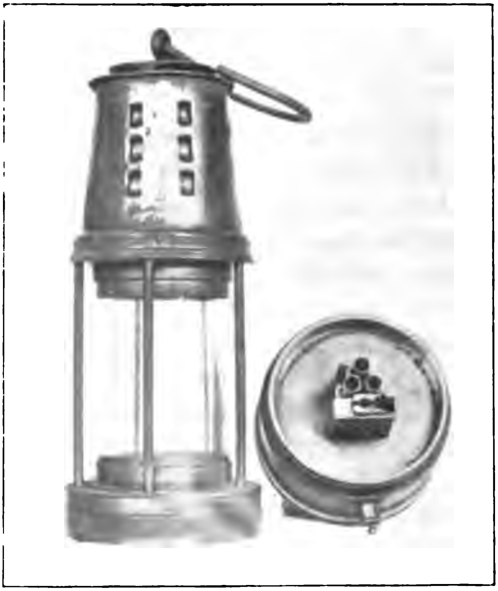


FIG. I.—Ashworth's patent tri-wick safety lamp, for burning petroleum spirit, and fitted with the Wolf patent relighter—Illumination equal to 1 1-5 standard sperm candles.

Mr. Hardie's remarks are also an extremely interesting chemical review of the dangers arising from mixtures of coal dust and firedamp, and are worthy of the closest attention. He says that he most carefully examined the East mine of the South West Virginia Improvement Co. to find traces of firedamp, but he does not say what lamp he used. This point is of the first importance because he goes on to prove that the lamps in use, and as used by men in general, will not indicate much less, if any, than three per cent. His report after examining the same mine with the Ashworth-Gray type, using alcohol as the testing flame, or with the hydrogen gas test introduced by Dr. Clowes and myself, Fig. 2, would be very valuable for comparison.

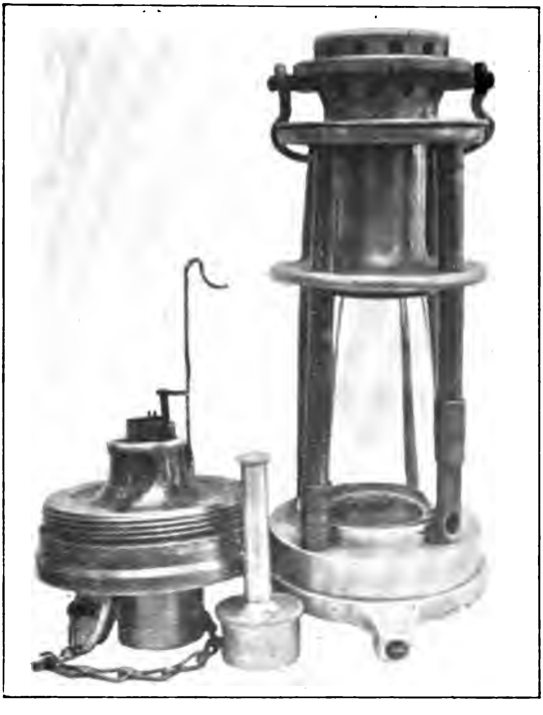


FIG. II.—Ashworth-Gray, with Stokes' alcohol spirit gas-testing attachment.

With regard to the percentages of firedamp which safety lamps will detect, I may say that I purpose testing ordinary safety lamps in measured mixtures of gas and air, and in course of a few weeks I may be in a position to reply more directly to Mr. Hardie's enquiry as to the percentages represented by certain caps, but in the meantime I may make the following general statement:—

If ⅛ in. of "cap" is seen on a testing flame which is ⅛ in. high, and the total height of flame from the top of the wick tube is a full ¼ in., it would probably indicate 2½ per cent. of firedamp. In like manner a ¼ in. "cap" would, if of a total height of ⅜ in. above the top of the wick tube, indicate the presence of 3½ to 4 per cent. of firedamp, and a ½ in. "cap," with a total height above the top of the wick tube of ⅝ in. would indicate about 5 per cent. of firedamp.

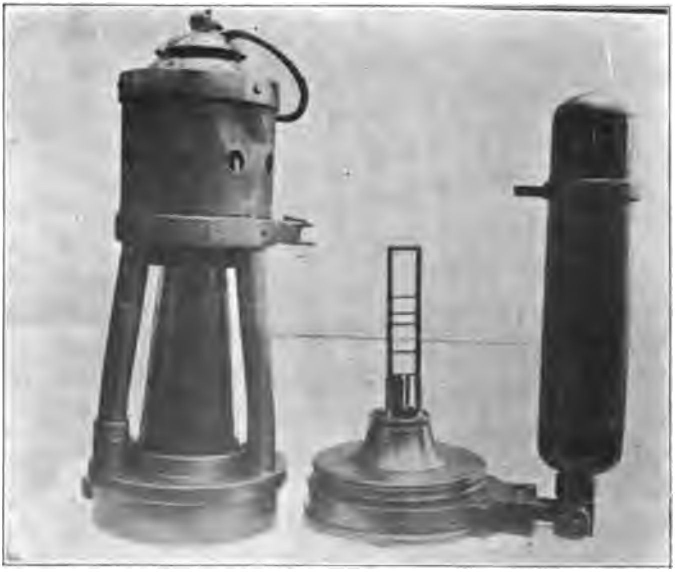


FIG. III—Ashworth-Gray safety lamp with Ashworth, Clowes & Co's hydrogen gas-testing attachment.

To give a list of "cap" heights with corresponding percentages of firedamp applicable to all types of safety lamps is impossible, as the height of the "cap" is entirely ruled by the heat of the testing flame, its non-luminosity, and the surroundings of the flame. The truth of this will be rendered clear by a comparison of the "caps" produced by oil and hydrogen flames of the same height; thus, supposing that the testing flames in both instances are a $\frac{1}{4}$ in. in height, and applied in the same type of safety lamp, the oil flame would produce a "cap" of $\frac{3}{10}$ in., whereas the hydrogen flame would give a "cap" of 1 in. high. Alcohol and benzolene would give shorter "caps," but much more distinct than a colza-petroleum flame. For further proof of this rule, if we take the hydrogen flame and increase its height to $\frac{6}{10}$ in., we shall find that the "cap" for 1 per cent. of firedamp has become 3 in. high. Roughly stated, a colza-petroleum flame "cap" indicating 5 per cent. of firedamp is only equal in height to that produced by the hydrogen flame when indicating 1 per cent. of firedamp.

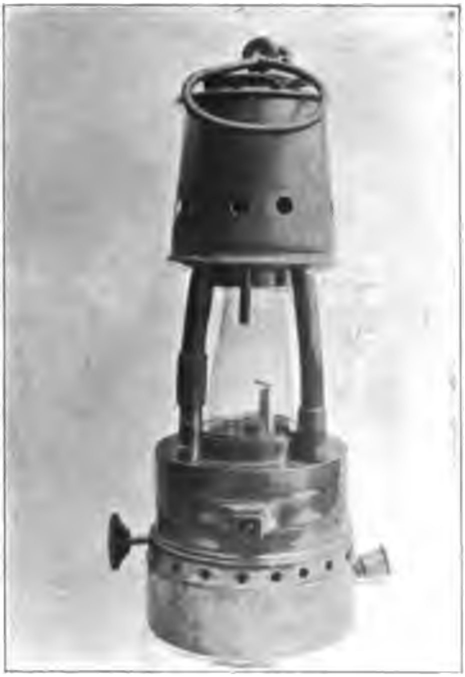


FIG. IV.—Ashworth-Gray with separate oil and alcohol spirit gas-testing burners.

Having thus obtained some idea of the great divergence in the percentage of firedamp indicated by "caps" ⅛ in., $\frac{3}{16}$ in. ¼ in. and ½ in. in height, it is still necessary to ascertain which of these "caps" is dangerous, if indicated on the reduced flame of the lamps in use in the majority of the collieries; and for information on this point we may turn to the Mines Accidents Report of 1886. In this report it is stated that neither the Davy nor the Clanny lamps will show 2 per cent. of firedamp, and therefore a "cap" of ⅛ in. high must indicate some percentage of firedamp in excess of 2 per cent. The Commissioners also reported that 2 per cent. of firedamp with the addition

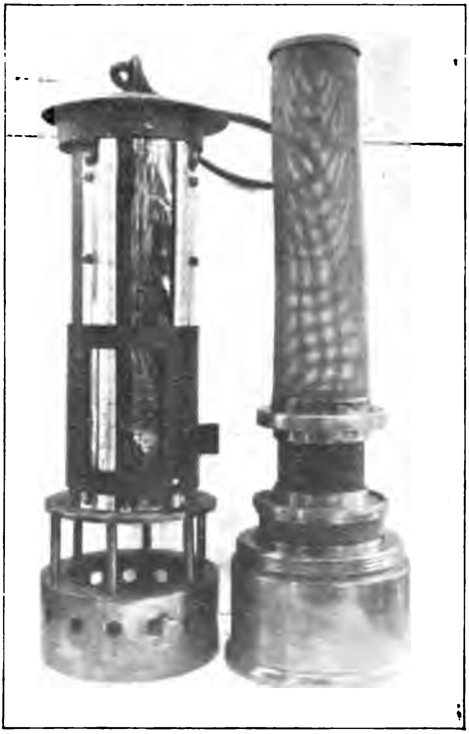


FIG. V.—G. Chesneau's alcohol spirit gas-testing lamp.

of a normal quantity (not a cloud) of coaldust is inflammable in the presence of an open light.

As probably many others besides Mr. Hardie are desirous of having all possible information on the point of danger when both coal dust and firedamp are factors, I may state from personal experience that the flame will pass out of a Davy lamp and explode the outer atmosphere, when the latter consists of a normal quantity of coal dust floating in an air current having a velocity of six feet per second, if 4½ per cent. of firedamp is added to the mixture. The life of a lamp under these conditions is only equal to 10 seconds purchase.

Mr. Hardie refers to the Clowes and Stokes safety lamps, and therefore I have added photographs of these lamps from which he and your members will see, without any added description, that both are what is known as the Ashworth's Hepplewhite Gray deputy lamps. The addition of the hydrogen test to this lamp was originally the Ashworth and Clowes patent, Fig. 2, and similarly the alcohol detachable arrangement is the Stokes patent, Fig. 3, and not the lamp.

As to the power of these lamps for detecting gas they are as follows:—(1) The Ashworth-Clowes hydrogen test; (2) the Ashworth, Fig. 4, Pieler, and Chesneau alcohol tests, Fig 5, and (3) the Stokes alcohol test, Fig. 3. That is to say the capacity of a safety lamp to detect firedamp is due to the heat of the flame and its non-luminosity and the hydrogen therefore possesses the highest qualification.

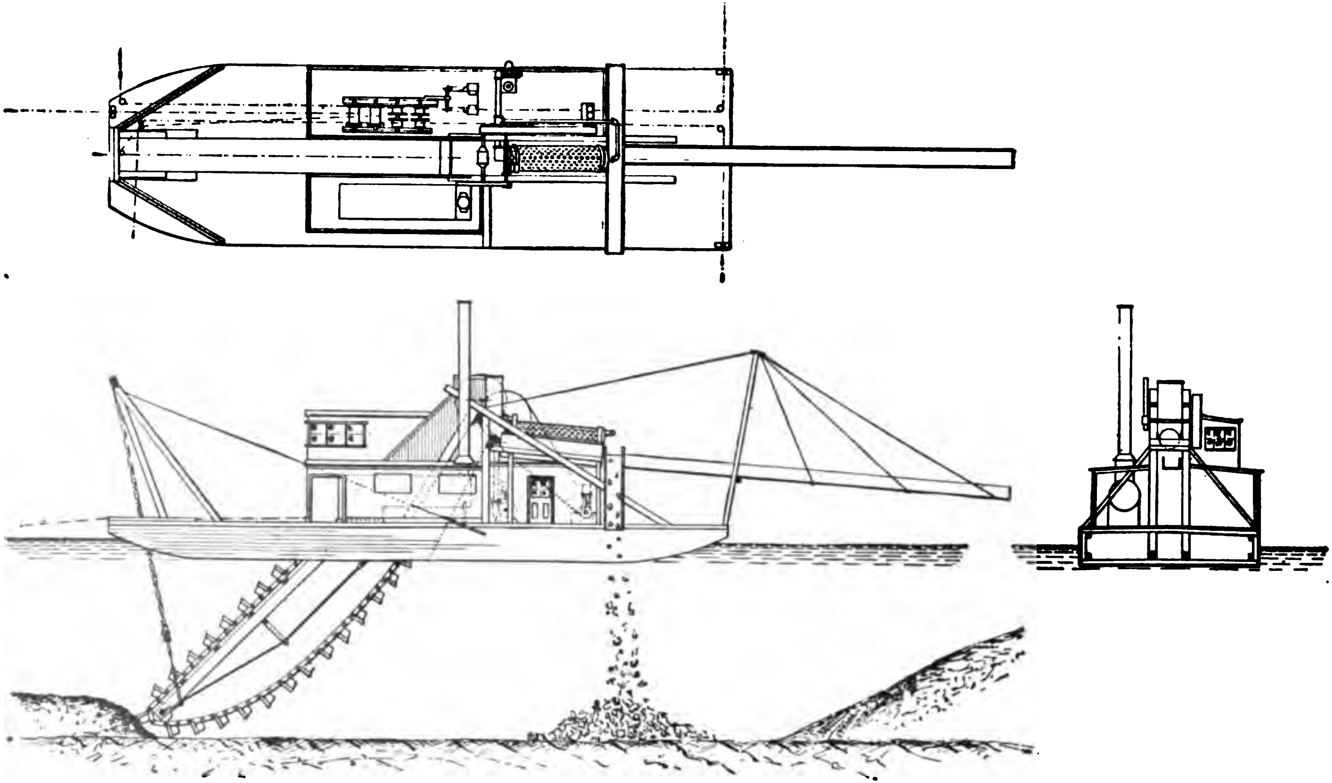
I need scarcely say that I shall be glad to add to these notes when requested, or to correspond with any member in relation to safety lamps.

The Stewart River Gold Dredge.

By A. W. Robinson, Montreal.

This dredge was built in 1902 from the writer's designs for Mr. William Ogilvie, Ex-Governor of the Yukon, for development of his claims on the Stewart River, Yukon. The hull was built and machinery erected by Mr. W. M. Ogilvie, and the machinery was supplied complete by the writer under contract for a lump sum. This dredge is a special design for exploration purposes being very light and strong and capable of working to a depth of 25 feet. It nevertheless has sufficient capacity to enable it to do effective work and to handle free material at the rate of 75 cubic yards per hour. In this way if there is any reasonable amount of gold in the ground to be prospected it can be made to pay although, of course, its earning powers will not be so great as a dredge of larger capacity. For the development of our northern rivers the writer believes it to be good policy not to make a very heavy investment at the outset in a large expensive dredge until the paying qualities of the ground have been thoroughly demonstrated. There is undoubtedly a need for a light and strong dredge of this type which will be primarily a prospecting dredge, which can be built and placed on the property for a comparatively small amount of money, and yet has the strength and capacity to enable it to make money if money exists.

The writer believes that the class of machinery that has heretofore been built for work of this kind has been entirely too heavy and cumbersome to send to such remote regions where the cost of freight is so high and the loss from breakdowns is great. This is due to the fact largely that the dredges have been built by manufacturers who naturally put into the machine the class of materials and workmanship which suited them best, and which may not have been in all cases to the interest of the purchaser and user. The Stewart River Dredge is designed and built entirely in the interest of the purchaser and user and it is as light and strong as it can possibly be made. To this end all



Stewart River Gold Dredge—Side Elevation, Plan and Cross Section important parts subject to strain, are made of the best quality of steel forgings or castings and as little cast iron used as possible, in fact, almost the only cast iron parts used in the outfit are the engine cylinders and the grate bars. These are of cast iron because no other material will answer the purpose so well. The arrangement of the parts is such that the various movements are accomplished with directness and simplicity and so that all the operations are under the control of one man. For facility in shipment the parts are sub-divided into convenient sizes and weights.

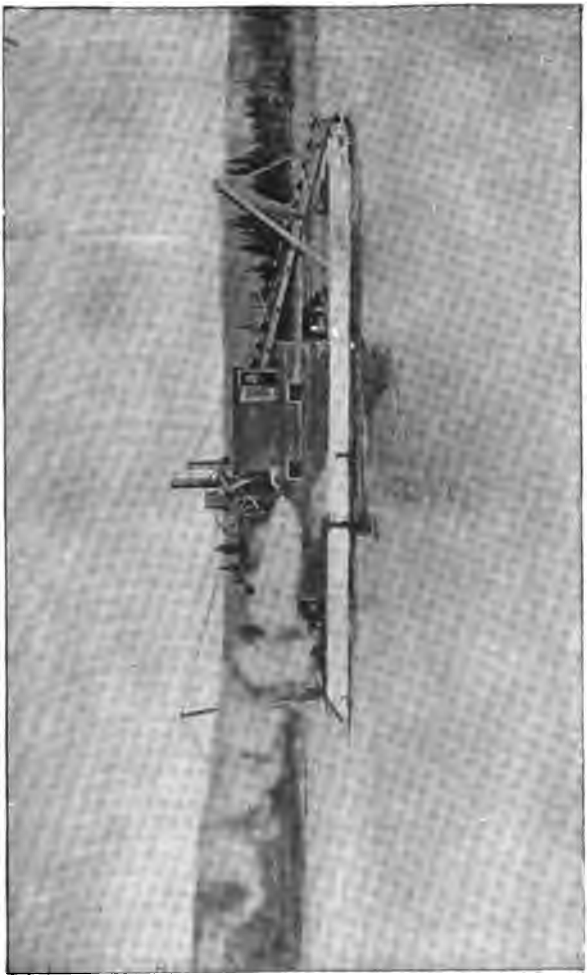
In carrying out the idea above outlined many radical departures from the usual construction were made, and a form of construction of the principal machinery was adopted after much consideration and study, which gives the greatest simplicity and the smallest number of parts that can possibly be used to accomplish the desired result.

The importance of simplicity and strength in a machine of this kind can only be appreciated by those who have had to struggle in a far off locality with a machine which was so complicated that it was difficult to keep it in order, and with certain parts so weak that they would break down. In a machine of this kind the presence of a single defective element is enough to nullify the advantage of all the rest which may be good.

The following is a brief description of the dredge:

The hull is of wood 85 feet long, 25 feet wide and 4 feet 6 inches deep, and is built of a form specially adapted to work in a rapid running river if required. The main framing is also of wood and consists or three main timbers on each side. These are connected in such a way as to hold the entire head machinery. The head frame timbers are connected by bracket castings of steel which also carry the ladder shaft so that no additional attachment is necessary for this purpose.

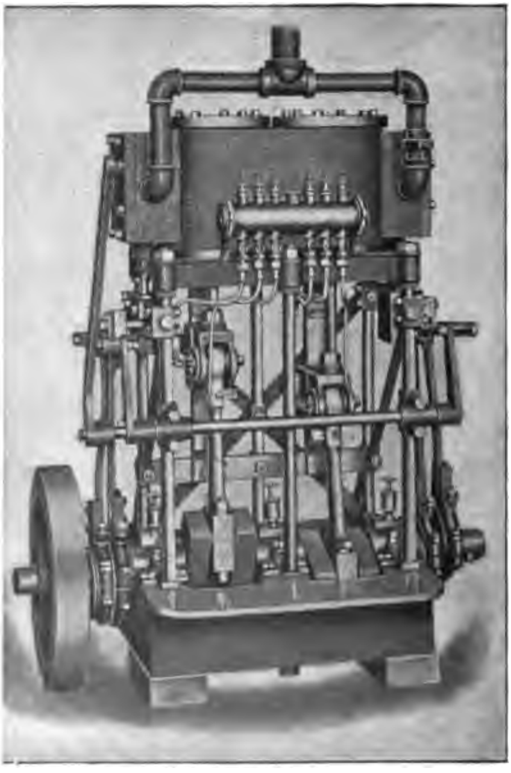
The dredge is fitted with a chain of buckets having a nominal capacity of 2¼ cubic feet each. These buckets are entirely of forged steel, no steel castings are used in their construction. Cast steel bucket backs are extensively used for elevator dredges, and the writer has also used them successfully for gold dredges, but where it is necessary to keep the weight down to the smallest possible limit a higher degree of strength can be secured and the liability to breakage through flaws in the steel casting obviated by making it of forged steel. The lip plates of the buckets are of the highest quality of machinery steel of such hardness that they will resist abrasion and at the same time will have the requisite toughness to resist breakage. The pins are of Hadfield's



General View of Dredge, in operation on Stewart River, Yukon.

Patent Manganese Steel, and all the pin connections are bushed with renewable bushings of oil tempered tool steel.

The material from the buckets is delivered into the hopper and passed through a revolving screen. The coarse tailings are rejected and the fine material passes through the screen into the sluice box and is discharged astern. This dredge, therefore, is of the coarse screen and sluice box type, as distinguished from the New Zealand type, which possesses a fine screen and in which the gold is saved on tables. The writer prefers this type of dredge, wherever it can be used, on the score of simplicity and also became large capacity can be reached with a



Main Engines 8″ x 8″.

comparatively small screen, and the tailings can be discharged astern and distributed without the necessity of employing a tailings elevator. The only objection that can be urged against the sluice box type is that it is not capable of saving the very finest gold, or at least, will not save as large a percentage of it as the fine screen and table method. This is, therefore, a question of adaptability to the character of the ground and the gold to be saved, and in the particular locality where this dredge is to be used the gold is sufficiently coarse to be saved in the sluice box. The action of the gold-saving part of the dredge is, therefore, precisely the same as in hydraulic mining, and as the tailings are discharged astern with a large quantity of water, they can be so distributed as not to enterfere with the work of the dredge. In special cases where the ground to be worked stands at a considerable elevation above the water, it may be necessary to employ a tailings elevator, but the writer has used dredges of this type which excavated their way through dry ground standing 10 to 12 feet above water, and disposed of all the material without any tailings elevator. The movements of the dredge are controlled by wire ropes attached to anchorages, or on shore, and operated by an independent steam winch. This winch is placed on the main deck and consist of six drums driven by a pair of independent engines. In the design and construction of this winch the ideal of keeping the weight down to the smallest possible amount has been fully lived up to, and at the same time the strength and efficiency has not been sacrificed but rather improved. There is no cast iron in this winch except the engine cylinders. The drums are of rolled steel plate with cast steel heads. The friction housings attached to each drum are of flanged steel plate with turned flanges. All the gears are of best cast steel and even the bearings in which the shafts are carried are steel castings of special and light design lined with babbit metal. The frame of the winch consists of two bars of flat steel to which all the bearings are bolted and which thus connects them all together and preserves the alignment and position of the gears. This bar frame is adapted to be bolted down on top of timbers on the deck. Each drum is fitted with independent clutch and brake. The clutch operating levers are mounted on the winch and project up through the floor of the operating room above so that they can be directly reached and worked by the operator without any shafts, bearings, links or connections being necessary or attached to the boat in any way. This in turn greatly simplifies the erection of the dredge. It is only necessary to set the winch on deck and bolt it down, when it is ready for work as soon as the steam pipes are connected.

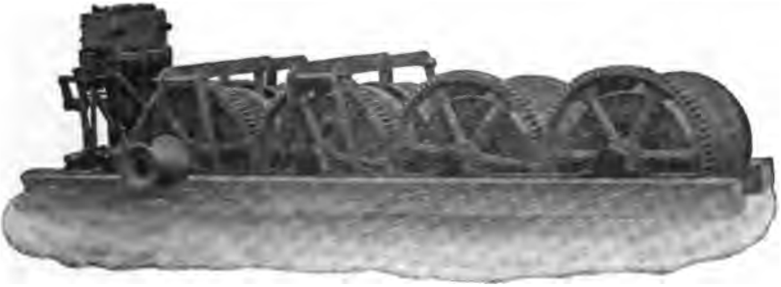
It may be incidentally mentioned that the time occupied in the construction and erection of this dredge was very brief considering the difficulties involved, and it is because of the simplicity of the design in little features such as these that the time of erection and completion was much less than ordinarily required.

Screen and Casing.

The engines for driving the winch are of the vertical torpedo-boat type with a cast steel bed plate and forged and turned steel column frames. The engines are fitted with link motion and are of the highest quality of design and workmanship. They are so small and light that they can readily be picked up and carried by one or two men, and yet they are sufficiently strong that they can haul the entire dredge up a current of 9 or 10 miles per hour and can perform all the movements of the winch with ease.

With high class machinery of this kind built entirely of steel and of light weight, not only is the cost of transportation reduced, but the liability to breakage during handling and erection also. If these parts, such as the drums and flanges of the winch, had been made of cast iron, as is ordinarily the case, they might easily be broken through handling or falling on the ground or otherwise injured during the vicissitudes of their long journey. With these light steel parts, however, no such risk is involved, and if by chance some parts should be injured or sprung out of shape through accident or a heavy blow it can be readily re-shaped and put back again.

The revolving screen is 38 inches in diameter by about 14 feet long. It is driven by steel gearing over the intermediate shaft of the head frame. A special method of driving this screen is employed which involves the use of very few parts and takes the power directly from the intermediate shaft. All the working parts are of steel and the screen is carried on four steel rollers. A special feature of this screen is that the perforated plates are built up on a steel frame in such a way that they can be readily replaced or renewed without taking down the frame or interfering with the driving mechanism. The holes in the screen are of large size being ordinarily calculated to permit about 80 per cent. of the material to pass through into the sluice box, only the larger stones being rejected. This practice is essentially different from the New Zealand type in which the holes in the screen are comparatively small so that only the fine material passes over the tables. In the present case the screen with large holes allows the material to disappear quickly and therefore, increases the capacity of the screen,



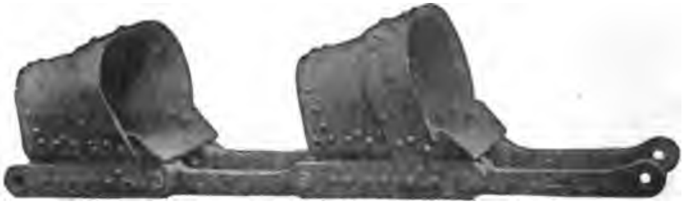
6-drum Winch.

and it also makes possible the disposition of the tailings without the use of the tailings' elevator, for the reason that only a small percentage of the material goes over the side, and which is not sufficient to obstruct the floating of the hull and the remainder is washed astern and distributed over a wide area by the combined action of the water and the movement of the boat.

The hopper into which the material is discharged by the buckets is also of steel and fitted with renewable lining plates.

The bucket ladder if of wood with steel fittings and truss rods.

The main engines are of the double high pressure torpedo-boat ype having cylinders 8 x 8 inches. The entire engines are of steel except the cylinders, which are of cast iron. The power is transmitted to the tumbler by means of a belt 14 inches wide and provided with a tightener pulley.



Buckets 2¼ cu. feet capacity.

The reverse levers and throttle valve of these engines are controlled from the pilot house so that the whole of the operation of the dredge is under control of one man.

Steam is furnished by one semi-portable return tubular boiler. It has a cylindrical shell 54 inches diameter by 14 feet long, and it has a very large fire box arranged under its entire length and adapted to burn inferior wood.

The water for sluicing purposes is supplied by one independent centrifugal pump having 10 inch suction and 8 inch discharge. In many of the New Zealand dredges the pump is driven from the main engines. The writer prefers to have it independent so that the water is under better control.

The hull is designed with ample space at after end so that gold-saving tables can be added at any future time if desired. The disposition of weight of the machinery upon the hull is such that it floats evenly and the draft of water does not exceed 2 feet.

The work of carrying out this enterprise as well as the erection and installation of the dredge on Stewart River was in charge of Mr. W. M. Ogilvie, and great credit is due to him for its accomplishment in so short a space of time in the face of many and great difficulties. The dredge was completed and put in service on the Stewart River just before the close of last season and could have worked a month if sufficient fuel could have been obtained. The parties, however, who contracted to furnish the fuel failed to fulfil their obligations, and as a consequence some time was lost. Sufficient was done, however, to demonstrate to Mr. Ogilvie's satisfaction that the dredge was a success, and also that it was well adapted to work the ground under the conditions as they there exist. So many mistakes have been made and so many enterprises of this kind have ended in failure that the public is not yet prepared to believe that this dredge will prove an exception to the rule, but we have here a machine that is carefully designed and well-built, and that can perform its functions without continually breaking down, and I am sure that all the members of this Institute will unite in wishing Mr. Ogilvie the success he deserves when operations are renewed in the coming spring.

The Future of the Coal and Coke Supply of British Columbia.

By W. Blakemore, M.E., Fernie, B.C.

The future prosperity of this province depends on an abundant supply of the best quality of fuel at a low price. This controlling factor is determined by two conditions—the general low grade value of our ores, and the fact that the geological formation forbids the existence of coal in proximity to the metalliferous deposits and so involves more or less costly transportation. This governs the conduct of our mining industry absolutely and as I shall be able to show further on is of equal force as applied to other important industries that may be established. The only important consumers of fuel not likely to be handicapped in this respect being the railways, and that because the matter of quality is not so important as in the case of smelting and manufacturing.

Steam Fuel.—As there can be no considerable development without railway transportation it may be well to consider first how our coal deposits will serve existing and prospective railways in British Columbia. The natural surface conditions will probably limit railway construction from east to west to three lines. In the north the Canadian Northern, from the Yellowhead Pass to the coast. In the centre the Canadian Pacific, from the Kicking Horse Pass to Vancouver, and in the south the Crow's Nest Pass, with some contination of the same by way of the Similkameen Valley to Vancouver. The difficulties and the cost of building across the mountain ranges of this province are sure to militate against more than these. The natural method of serving the interior will be by means of branch lines running north and south between the mountain ranges. In order that transportation may be as cheap as possible it is necessary that these main lines should pass through or near to large coal deposits of suitable quality for steaming, at any rate this is a present necessity and will remain so until some day, in the possibly not very distant future, when our magnificent water-powers are harnessed to electric locomotion.

The main line of the C.P.R. has hitherto been well served with fuel by the Canmore mines, and it is likely that for at least ten years these will continue to furnish all that may be required. The unworked area, however, is not large, and already it is time to look further afield. On the eastern slope of the Rockies, eight miles west of Calgary, we have exposures of coal seams running north and south which are probably continuations of the large bituminous coal field lying to the south. Little or no development work has been done at this point but the exposures are consistent with the theory named and I have little doubt that a season's work would show up a series of seams of good quality. A line can be gotten as to this by examining the coal at Sheep Creek which, though inferior to that at Canmore, is still of fair quality and such as could well be used in the absence of a higher grade. Recent investigations convince me that the coals found in the Blairmore district, and as far south as the entrance to North Kootenay Pass, continue northwards parallel to the Rockies far beyond the Yellowhead Pass and, if so, although they are on the Alberta side, they are in an ideal position to furnish steam fuel for the main lines at least half way across the province of British Columbia.

As far as the Canadian Northern is concerned, no portion of this system has yet been constructed, but the route has been surveyed from the Yellowhead Pass to the coast and at three points, at least, good steam coal has been located in large quantities. Two hundred miles east of the past, upon the Saskatchewan River, a high class lignitic coal has been discovered yielding on analysis.

Fixed carbon................	52	per cent.
Volatile combustible matter..	35	"
Ash...........	12	"

This is about the same grade as the Lethbridge coal of which more than 1,000 tons a day is mined in the season for steam and domestic purposes, and which is a far superior coal to that used by the Great Northern south of the International line.

At a point 200 miles west of the Yellowhead Pass outcroppings have been met with by the surveyors and at the moment these are being traced. They, no doubt, represent the northern continuation of the Cretaceous measures and, if so, the quality will be that of a high grade bituminous coal, and the only question will be as to the extent.

On the Pacific coast, 400 miles north of Vancouver, there are extensive coal seams near the route of the proposed railway. The measures run north and south, and the average of several samples recently taken by a reliable expert shows:—

Fixed carbon	54	per cent.
Volatile combustible matter	37	"
Ash	14	"

This coal, although high in ash, compares favorably with the fuel recently used on American lines in the west.

Coming to the Crow's Nest line and prospective continuation to the coast, we have the highest grade of steam coal known on this continent in the Crow's Nest Pass and its extensions, and it is not necessary that I should say anything about it except that its only limitation as a railway fuel is one of distance. It will always control the market for this purpose as far west as the Arrow lakes, but recent discoveries farther west tend to show that as the Columbia and Kootenay extension is built it will open up new coal fields which, by reason of their shorter haul, will secure this trade.

On the north fork of Kettle river, outcroppings of high class bituminous coal have been found and are being traced. My own analysis of a sample taken from a 4-ft. seam gives:—

Fixed carbon	62.6	per cent.
Volatile combustible matter	29.6	"
Ash	7.8	"

If any considerable quantity of such a fuel as this can be found it will dominate the steam coal trade from the Okanagan lakes east to the Arrow lakes, but it lies nearly 100 miles north of the boundary district and out of the route of the proposed railway, although it can only be a question of time until a branch is constructed up the Kettle river. Farther west we have two well defined coal fields near Princeton and Nicola. The former, with Ashnola as its centre, is undoubtedly upon the route of any railway from the Boundary district to the coast, as such a railway must pass up the Similkameen valley at least as far as Princeton, whatever route it may take thence westwards. Here we have a well defined coal basin 8 miles from east to west and 10 or 12 miles from north to south, many seams of lignitic coal outcrop of which a fair average analysis gives :—

Fixed carbon..........	42.0	per cent.
Volatile combustible matter.....	42.7	"
Ash	3.0	"

In the absence of a better fuel this would be used by the railway from the Boundary district to the Hope mountains. Only a month ago, however, a 9-ft. seam of good coal was bored through at a depth of 625 feet, which yielded:—

Fixed carbon.....	54	per cent.
Volatile combustible matter	23	"
Ash..........	8	"

This is full of promise for the future and there are, doubtless, other seams of equal if not superior quality. Thus, the supply of an excellent steam coal for the Columbia and Kootenay is assured.

At Nicola (near which the projected railway will pass if it joins the main line of the C.P.R. at Spence's Bridge) there is an extensive coal field, probably of the same character as the Princeton basin, which would be easily available.

If in connection with these various sources of supply it be borne in mind that we have extensive coal mines in full operation on Vancouver Island, you will see that every part of the province is well furnished with good steam fuel and that the first essential for cheap transportation abounds wherever an important railway is likely to be constructed. I estimate that on the Canadian Northern the maximum haul of steam fuel within the province will not exceed 250 miles ; on the main line of the C. P. R., 200 ; and on the Crow's Nest line, 150. This should give fuel at an actual cost ranging from $2.00 to $3 00 a ton, a figure which would certainly be favorable for the development of the province on the lines of cheap transportation. These figures take no account of other discoveries which will be made in the near future, as there are abundant evidences that there is a continuity in the coal seams of the Rockies, from Mexico to the Yukon ; and there are few valleys of British Columbia in which some trace of these does not exist.

Smelting Fuel.—We now have to consider the subject of smelting fuel and probably this will appeal more directly to our members because it "comes home." Without cheap and good smelting fuel the mining industry of British Columbia would come to a standstill. The men who were reviled in 1895 for pronouncing our ores "low grade" have had an ample revenge, and it is now not merely a proven, but an acknowledged fact. Transportation and treatment on Rossland ores have been reduced from $13 to less than $5 a ton, and shipping values from $25 or $30 to $8 or $10. To this result the Crow's Nest coal and coke have contributed not a little, having brought the delivered price of the former down from $12 to $4, and the latter from $17 to $6. During this period we have learnt many things, and some yet remain to be learnt. It must now be admitted that our ores are so low grade that every cent in cost tells, and that to develop the industry will require the cheapest fuel that can be obtained. Take for example the great self-fluxing copper district, the Boundary. Is it taking too low an estimate to say that with the exception of a few rich chutes, which may run to $7 or even $8, the vast bodies of ore in that camp will not exceed $4 ? If this is so, and if, as Dr. Ledoux says, fuel represents 65 per cent. of a total smelting cost of $2, then every dollar saved in fuel would mean about 25 cents on the ton of ore treated, a sum which probably represents the difference between profit and loss since it is admitted on all hands, and confirmed by the highest experts, that everything has been done in the way of appliances and economic management to reduce the cost of treatment to the lowest possible figure.

Let us enquire then how the future of smelting in British Columbia is likely to be affected by the fuel question. This practically resolves itself into the enquiry—how can smelting fuel be still further cheapened? There is only one way, by competition. This involves the development of other coal fields and the liberation of some portion of the Government coal lands in the Crow's Nest Pass.

First, as to the opening up of other coal fields. At the moment of writing there is, so far as I know, only one place in the interior of British Columbia (outside of the Crow's Nest Pass) where coal of a suitable quality for making a first-class smelting coke has been found, viz. on the north fork of the Kettle river. The analysis was given under the heading of "steam fuel." If this deposit should be large enough the quality is all right, and the location being only about 100 miles from the Boundary district, would give it an advantage of at least $1.50 in cost of transportation and would save 40 cents a ton in treating the ore.

The same coal would serve any smelters that might be erected farther west in the event of no coking coal being found in the Similkameen or Nicola valleys, where it is certain there are valuable copper ores and at least three promising camps—Twenty-Mile Creek, Copper Mountain, and Aspen Grove.

For any relief in the cost of fuel in East Kootenay and the eastern camps of West Kootenay, we have to look to the Crow's Nest Pass coal field. Leaving for later consideration the Blairmore section of this (because it is in Alberta) we are confined to three sections, viz.: the coal areas owned and operated by the Crow's Nest Pass Coal Co.; those lying to the south beyond the B. C. Southern reserve in the neighborhood of Lodge Pole creek, Greenhills and Wigwam river; and the 50,000 acres recently selected by the Dominion Government. The former are being developed slowly and having regard to the statement made by the managing director that, in addition to the home market, the Great Northern company require 10,000 tons a day, it is not likely that this demand will be overcome for many years. In addition, the liability to accidents like the recent deplorable disaster, and to strikes, renders it extremely undesirable that the fuel supply upon which every industry in the Kootenays depends should be in the hands of any one firm however competent and well-meaning. Then there is the impossibility of getting the lowest possible price from a monopoly. At the moment the charge for coal is $2 and for coke $4 a ton at the ovens. As I shall show, effective competition would reduce these figures to $1.50 and $3 at the ovens, and possibly a little lower. The actual cost of shipping one ton of coal need not exceed $1 and will almost certainly be less after allowing for every item of charge. This would give coke at a cost of $2.25 to $2.50 and leave a margin of 50 cents profit on coal and 75 cents on coke, which is at least double the average rate of profit on coal and coke in the Eastern States or in England over the last twenty years. The present British Columbia consumption of Crow's Nest coal is 1000 tons and of coke 300 tons a day, and a reduction such as the above would mean a saving to the industries of the Kootenays (and mainly to the mining industry) of about $1,000 a day or $300,000 a year. As the country is growing so rapidly this tonnage would be largely increased in the near future. From what areas could fuel be produced at these figures? Possibly from the sections south and east of the B. C. Southern reserve already referred to. That, however, is at present a matter of speculation, because nothing has been done beyond locating the coals, and until development work has been carried to a much more advanced stage, it cannot be stated with certainty whether the measures are sufficiently continuous and regular to yield a large working area. In any case it will take two years to prove this and will involve the building of a branch railway nearly thirty miles up Lodge Pole creek.

If, however, the Government would liberate say 5,000 acres of their selection adjoining, and on the south side, of Morrisey, all the conditions exist to bring about the result I have foreshadowed. At this point the coal seams of the basin are exposed and are most accessible. The measures are regular and dip under uniform strata to the east for several miles until they meet the eastern upthrow which terminates the basin. From exploratory workings conducted here last season I got samples yielding the following analysis:—

No. 1—18-ft. Seam.

Fixed carbon.................	78.7 per cent.
Volatile matter..................	17.0 "
Ash.........................	4.3 "

No. 2—4-ft. Seam.

Fixed carbon	77.3	per cent.
Volatile matter	18.4	"
Ash	2.8	"

These figures show that the celebrated coals of the Crow's Nest Pass are at their best on Morrissey creek as a comparison with the following samples taken from two other points in the Pass indicates:

Fernie—6-ft. Seam.

Fixed carbon	69.14	per cent.
Volatile matter	25.45	"
Ash	3.62	"

Michel—14-ft. Seam.

Fixed carbon	62.40	per cent.
Volatile matter	24.10	"
Ash	12.05	"

This is the only point where coal of equal quality to the best Fernie coal has been discovered and explored sufficiently to enable me to speak with certainty of its extent, and in this view I am confirmed by Mr. J. McEvoy, former Government geologist. In the interests of the Province, and especially of the mining and smelting industry, no effort should be spared to induce the Government to place this area on the market. There is no legal impediment or obligation in the way and I have little doubt that an unanimous request would attain a result so important to the future of the Kootenays in particular.

This brings me to consider another source from which relief may come in any case through the ordinary healthy channels of competition. I refer to the Blairmore coal field. Having done most of the prospecting work that has been done here this year I am able to give you the latest information. Here we have what I believe to be the same series of coal measures as are found in the Pass, only instead of having been uplifted in the form of an elongated basin or trough they are uplifted and fractured in longitudinal lines and exposed in ridges running north and south, or nearly so, parallel with the Rockies. The result is much folding and duplication, but at the same time many more exposures of the same seam, and increased facility of access.

These conditions have been proved in extensive properties owned and controlled by Mr. Leslie Hill, Mr. T. G. Proctor, Messrs. McVittie and Leitch, Messrs. Davenport and Paine, and others. The coal seams, which correspond in thickness and occurrence with those of Fernie and Morrissey, have been traced from the entrance to the north Kootenay Pass where Mr. J. J. Hill has secured 10,000 acres to a point 20 miles north of Blairmore. Messrs Frank and Gebo have developed a successful mine on the east side of Turtle mountain which has already attained an output of 800 tons a day, the coal being excellent for steam purposes. My own object in taking up certain bonds in this important coal field was to determine its character for coking purposes and to ascertain how it compared with Fernie coal. The result you can best judge from the following analysis taken by me from comparatively shallow workings; the ash is certain to be less at greater depth:

	Fixed Car.	Volatile.	Ash.
No. 1	63.4	29.1	7.4
No. 2	64.5	26.5	9.0
No. 3	67.7	25.5	6.8
No. 4 (20 miles north of Blairmore)	58.9	28.5	11.8
No. 5	60.3	31.3	7.4

Samples Nos. 1, 2 and 3 are all first-class coking coals, Nos. 4 and 5 good steam.

This coal field is so near to the province of B. C. that it will seek its natural market there for coal and coke, especially the latter, and the mode of occurrence of the seams being more favorable for cheap working than in the Pass, there is no reason why the cost of production may not offset the extra transportation, a matter of 30 to 50 miles. At any rate I am convinced that in less than two years from date we shall see coal and coke of satisfactory quality being produced in this district at the figures I have already named, to the enormous benefit of the various industries of southern British Columbia.

Air Compression by Water Power—The Installation at the Belmont Gold Mine.

By D. G. Kerr, C. & M.E., Cordova, Ont.

This water power is situated in the township of Belmont, county of Peterborough, Ontario, about three miles in a north-west direction from the Belmont Gold Mine.

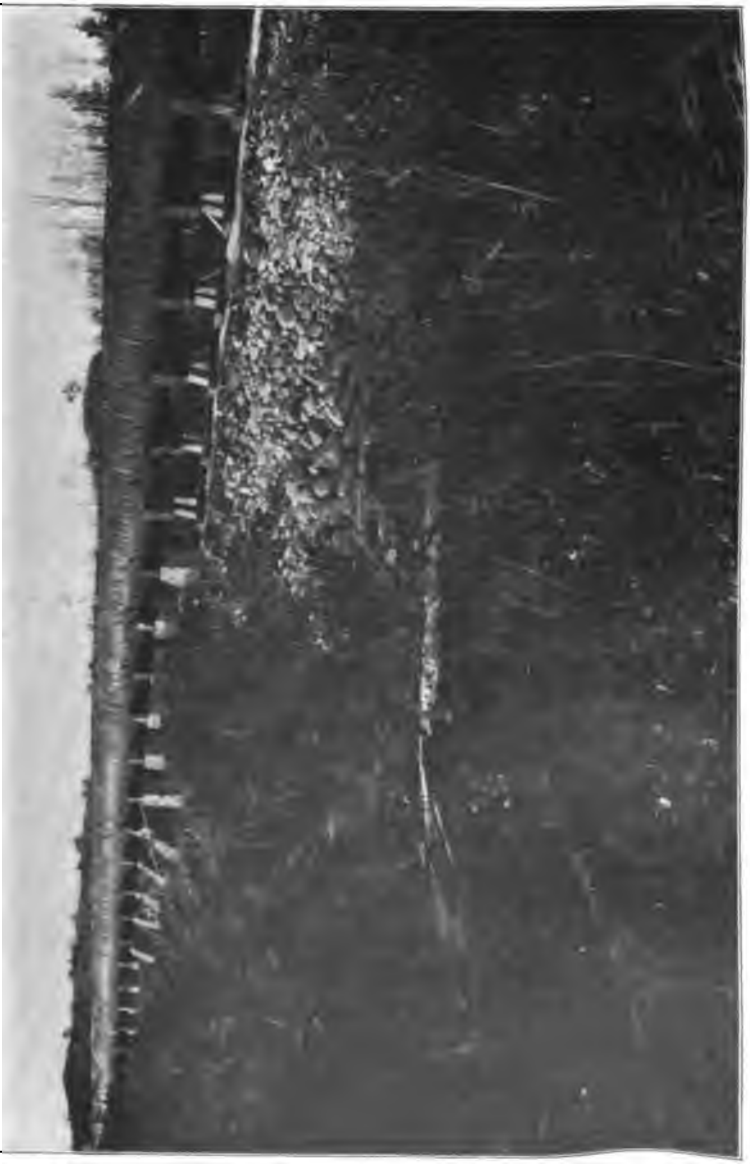
On the outlet of Deer Lake there are falls and rapids which give a head of 75 feet in a distance of 1,600 feet. Still further down the river there is another drop of 25 feet, all being on the property of The Belmont Gold Mine, Limited, Cordova, Ontario.

Deer Lake is about four miles long by a mile wide and holds a splendid reserve of water for the dry season. The lake is fed by a chain of smaller ones which extend north about 100 miles. This makes an ideal situation for a power plant.

After the power was acquired the question was electricity or compressed air. The generation and transmission of electricity would have cost less at the power house and to the mine, but it would have been necessary to have put up a motor driven air compressor at the mine to supply drills with air, and motors at hoists and engines. This would have brought the first cost of the electric installation to a higher figure than one large air compressor plant, besides, the attendance, etc., at the motor driven compressor at the mine would swell the working costs. By installing one large air compressor at water-power and carrying the compressed air in pipes to the mine, branching it off in all directions to the shafts and mill, without having to make any alterations on any of the engines or hoists, all that was then required to be done was to shut off steam and turn on air to the engines, hoists and pumps without any loss of time when air was turned on at power plant. This left the steam plant boilers, etc., with all their connections, as a good reserve power in the event of anything going wrong with the air power. In this arrangement, it permits the using of machinery which was comparatively new, being only two or three years old.

One important point was the getting in of an air compressor plant

Lower part of Flume and Power House—Belmont Gold Mine.



Centre of Flume Pipe—Belmont Gold Mine.

large enough to do the mine work for a long time to come. As the underground requirements for air increased there could be more power developed at the falls by electricity to work the surface machinery. Then would be the time for considering the motor driven machinery as by that time the proper size of machinery for handling the quantity of ore would be better understood.

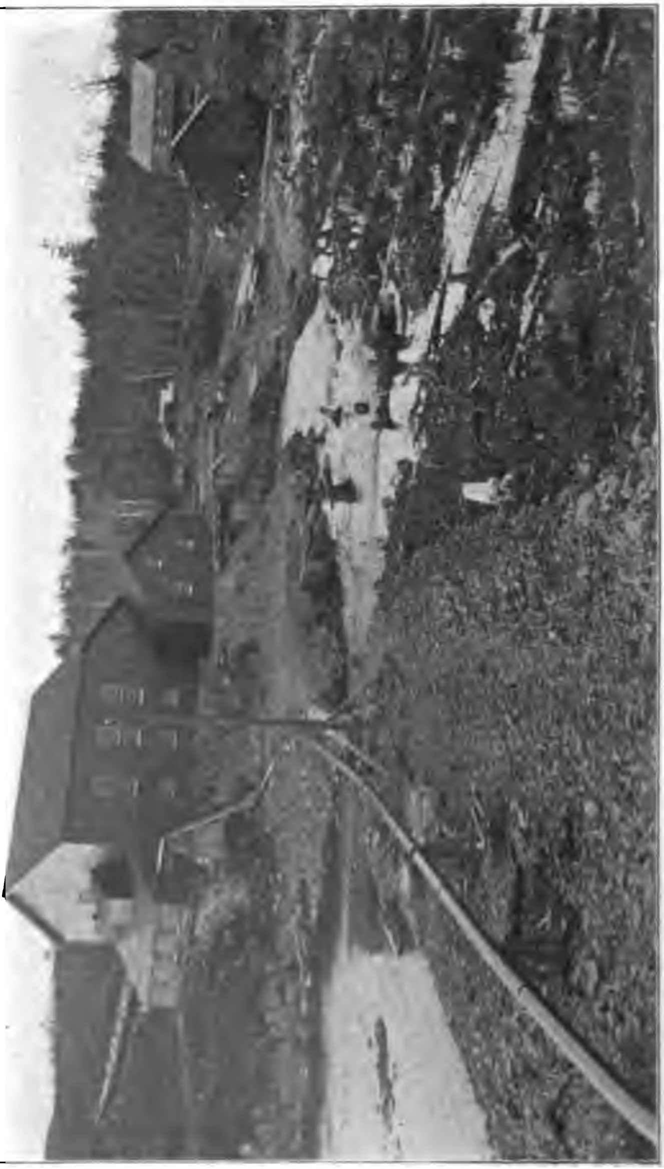
The outlet of Deer Lake was formerly by two channels, 300 feet apart, through a fine grained Diorite rock. The south channel was closed with a concrete and cement masonry dam, 85 feet long, 9 feet wide at top and 16 feet at base and 15 feet deep at the greatest part.

On top of the dam are small piers 18 feet apart for bridging with timbers for a passage across. Underneath this and over the top of the dam the surplus water goes when stop logs are in at the slide way on the north dam. The north dam is 75 feet long with a 25 foot slide for the passage of logs. In front of the north side is a forebay with a 30 foot rack. This is where the water is taken out of the lake for the power, through a 7 foot square opening in the dam, with a gate on the side next to the lake. The gate is worked by means of a rack and pinion wheels wrought by worm shaft and wheel. The water intake to the flume is reduced from 7 feet square to cylindrical by means of steel work with flanges and fasteners for the wooden staves of flume pipe. On top of the dam, behind the gate, and going down into the water entrance of the flume pipe is a man or air hole. Without such, the shutting down of gate at the dam, allowing the water to pass through the wheel, would create a vacuum in the flume, causing a tendency to collapse or disturbance to staves, resulting in much trouble and annoyance through leaks when water was turned on again.

The flume pipe is 1,550 feet long, 6 feet internal diameter, and made of 2½ inch pipe staves, 6¼ inches wide, radial edges, butt joints with saw drafts, cut 2 inches into both ends, into which was placed a steel plate ¼ of an inch wider than the stave to embed into the staves on both sides. No two joints come together, but at irregular intervals, the staves being cut in 12, 14, 16 and 18 foot lengths and clamped with 2000 3-16 x 2 inch steel bands, and fastened with grip fasteners. The pipe is carried on 12 inch square timbers circled out to take the outside circle of the flume, and these bearer timbers are placed 8 feet apart, centre to centre. The steel bands are spaced 3 inches apart at the lower end and 24 inches at the top. There are two curves in the flume of 20° each. The 6¼ inch staves were too wide and rigid to be sprung into place on the top of the flume, so ⅓ of the top staves going round the curves were made 3⅛ inches wide.

The bed for the flume was cut through ridges of rock for the first 900 feet from the dam, 3,960 cubic yards of rock excavation being done by steam drill in the winter season. At the lower end there is 217 cubic yards of stone piers to carry the flume over a low piece of ground before arriving at the power-house, and inside of the power-house a steel tube takes the place of wooden staves.

The cost of the wooden flume, made of pine, came out at $3.00 per foot, while the estimated price for this length of steel (flume only) was $15.00 per foot. The power-house building lies north and south and the part which contains the compressor is 40 x 50 feet. South of this is a cooler room 43 x 16 feet, and north of the main part is the water wheel part, 64 x 35 feet. The water-wheel is a double 50 inch bronze Leffel wheel with double discharge and running, at 210 revolutions, has a capacity of 800 horse-power, taking 7,500 cubic feet of water per minute. The water gates of the wheel are made of cast steel, and the casing of ½ inch steel plates with cast iron heads. The water-wheel is carried on a steel shaft which extends at one end for the transmission of the power by means of a rope pulley, 5 feet in diameter and 6 feet 4 inches wide across the face, with 30 grooves for 30 1¾ inch cotton ropes. On the top of wheel casing is a dome 2 feet in diamerer by 10 feet high with valve, and just above this valve are two pipes, 12 inches in diameter, having spring valves and leading into draught tubes. This is an arrangement for the relief of undue pressure from water ram, such as might be caused by the water-wheel gates on a long flume through which water is travelling at a certain rate, being shut down quickly. This arrangement takes the place of a stand pipe; costs less, and there is no danger of its freezing, as it is all



Power House, showing Tail Race and Air Pipe leading to Belmont Gold Mine.

Flume Pipe. Upper part Dam in the distance.

under cover. On wheel case is a guage showing water pressure and head in feet, and on draught tube is a vacuum gauge giving the vucuum in inches. The vater-wheel, wheel casing, etc., were furnished by The Wm. Hamilton Mfg. Co., Peterboro, Ontario.

Underneath the wheel is the tail sump, and from that the tail race going into the river. This was excavated out of solid rock to a depth of 20 feet and has cement masonry walls with steel beams and bolts with which the wheel casing is held in place. The tail sump is carried west underneath wheel to take the water from another wheel of 350 horse-power for which there is provision for water made on the steel part of flume by means of a tee piece. When this other wheel is at work the water velocity through the 6 foot flume will be brought up to about 10 feet per second. The intention is to develop this 350 horse-power with a direct driven dynamo, alternating current.

The air compressor which is driven by these 30, 1¾ inch cotton ropes from pulley on water wheel shaft is one of Walker Brothers', (Wigan, England), Patent Air compressors; compound horizontal principle; high pressure cylinder, 30 inches diameter; low pressure cylinders, 48 inches diameter, with a 4 foot stroke. The cylinders are water jacketed, provided with improved accessable inlet valves and fitted with metallic packing on the piston rods. It is rope driven by means of a 20 foot pulley, 6 feet 4 inches across the face, weighing 60,500 lbs., and built in sections on massive concrete and cement foundations, 14 inches high. Running at 65 revolutions, or a piston speed of 520 feet per minute, it will have a capacity of 6,500 cubic feet of free air per minute.

The low pressure air cylinder intake is connected together by branch pipe from the 3 foot pipe to the atmosphere outside. This 3 foot pipe lies horizontal on the top of the low pressure air cylinder, one end going to the south and the other to the west end of the building. The air is compressed in the low pressure cylinder to 30 lbs. pressure and is then discharged through a 14 inch pipe to the intercooler, and from there after being cooled, to the high pressure cylinder from which after being compressed to a pressure of 100 lbs. per square inch, it

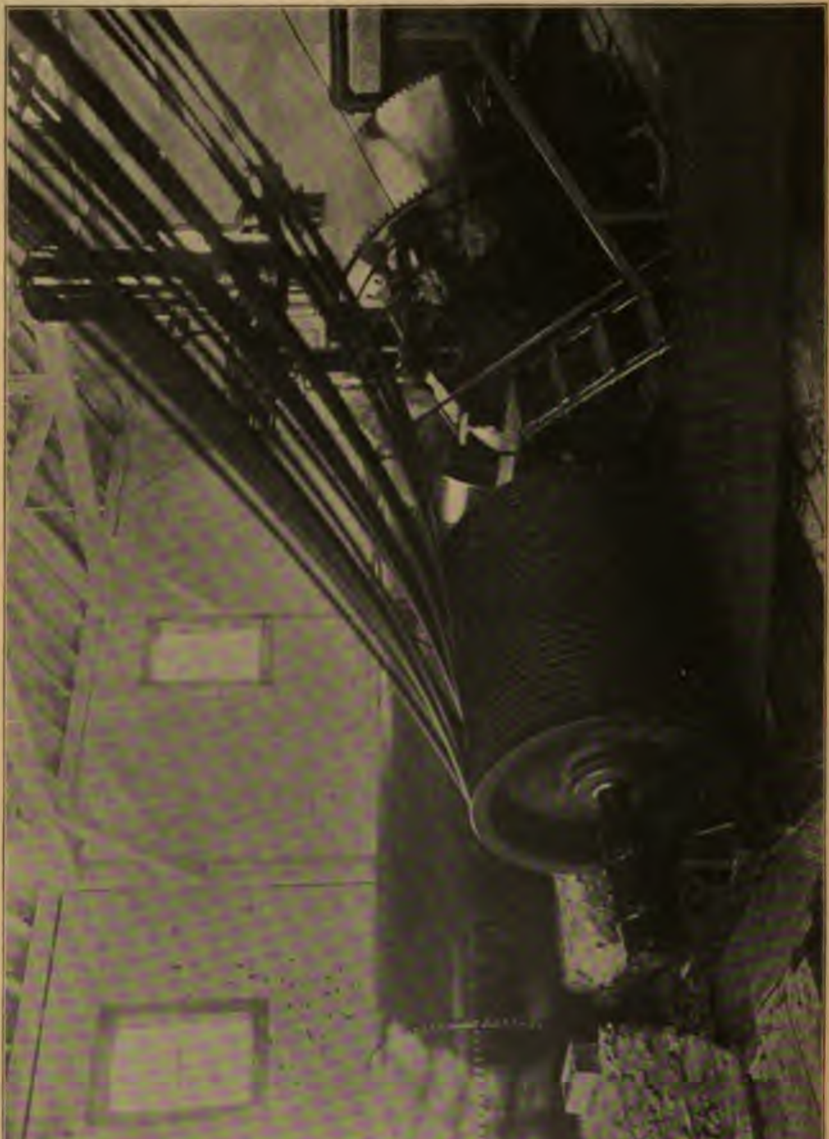
passes into the after-cooler. The inter-cooler and after cooler are filled with brass tubes through which flows cold water and the compressed air passes and repasses over the outside of the tubes and is cooled down to within 10° of the temperature of the water used. In this cooling process there is considerable moisture deposited, as it is only by cooling the air to the lowest temperature that a high extraction of the moisture can be had.

The air leaves the after-cooler through a 12 inch pipe or ordinary oil well casing, having fine screwed couplings and tested to 600 lbs. pressure. Half a mile out from the compressor is an air receiver to collect any moisture which may have passed the after-cooler. This moisture is drawn off every day.

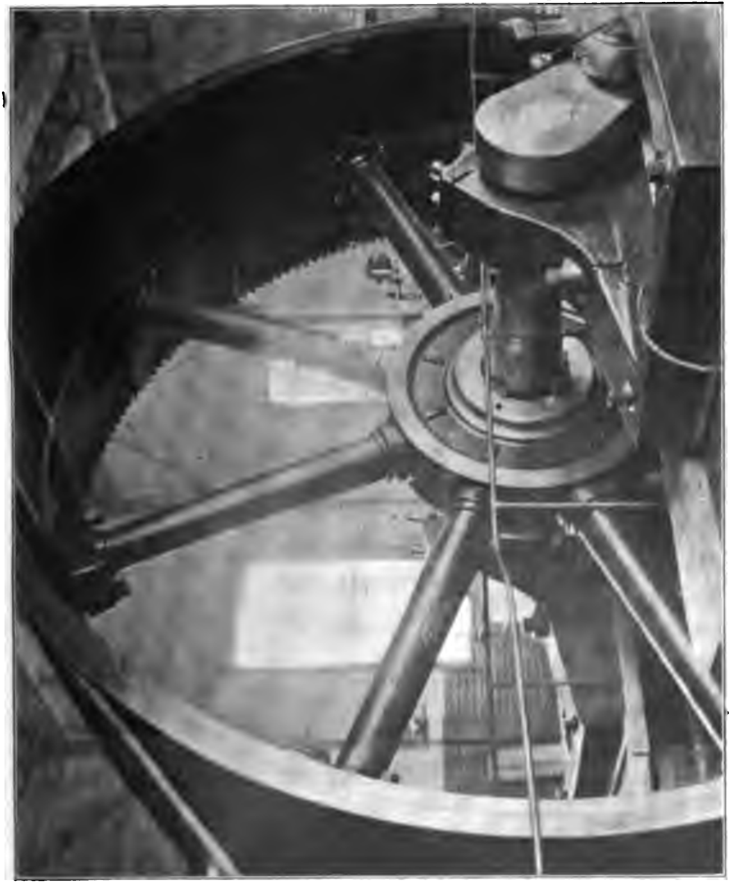
The 12 inch pipe line from the compressor to the mine is 15,000 feet long. At the end of this pipe line at the mine is another air receiver to collect any moisture which may have been carried into the pipe line. The only time of the year that any moisture is expected to be carried this length, is when spring sets in and the heat of the sun frees any moisture from the inside of the pipe. This will be very little as the air receiver near the compressor is in low swamp, and the air line leaving it for the mine has a gradual raise of 50 feet in the 2,000 feet, thus draining moisture back into the receiver. The pipe line has 18 expansion, joints and is mostly all buried in sand to prevent expansion and contraction.

The foregoing is only a slight description of the plant. As it was only started running in August 1902, and has not been run up to its full capacity yet, the loss in pressure due to friction in transmission cannot very well be arrived at. The loss at present is less than 1 lb., but, using the full quantity of air, the loss is expected to be 3½ lbs. What I would like to have completed, but found impossible in the short time that the plant has been running, is a complete comparison between summer and winter of the temperature at which the air is taken into the compressor, the amount of moisture extracted and the temperature of water used in coolers.

During the past winter there was only one shut down owing to



Water Wheel Section, Rope Pulley in motion—Belmont Gold Mine.



Rope Wheel on Compressor—Belmont Gold Mine.

freezing. This was caused by the moisture in the receiver half a mile out from the compressor being allowed to freeze through not being drained off every day. The ice formed in a honey-comb form until it interfered with the air pressure at the mine, reducing same to 65 lbs. while there was 105 lbs. at the compressor. Shut down and found the receiver full of this honey-comb ice. After taking out same, started up again and covered up the receiver with a shed, banked so as to keep off the intense frosts, and permitting the moisture to be drained off.

At the mine I have had no trouble with freezing up except with a Corliss engine and a 14 inch Duplex pump. I find that engines with slide valves give no trouble, due to non-expansion of air inside of cylinder.

Genesis of the Animikie Iron Range.

By F. HILLE, MINING ENGINEER, Port Arthur.

PREFATORY NOTES.

When we contemplate writing upon some certain subject, which has also been dealt with by a number of other writers, it is absolutely necessary to read the principal publications, at least, in order to see whether we may not be duplicating what is already a matter of common knowledge, or whether there may not be something previously written on the same subject which might to some extent prejudice our efforts.

Accordingly, before commencing work upon this paper, I came across certain notes in one monograph, which, if overlooked and not rectified by me, might have caused some of my own statements to seem peculiar. I must therefore ask the indulgence of my readers if I have to devote considerable space to the refutation of the statements of this monograph, even though it may place the principal subject of this paper in a more subordinate position.

When we take into consideration the immense field which would have to engage our personal attention and study, it may well be imagined that it is next to impossible to become thoroughly versed in the geological conditions of every locality from personal examination, and we therefore are compelled to rely oftentimes on the published observations of others or perhaps to some extent on hearsay information. Thus it will sometimes happen that we may make statements which, after personal examination, we would never have made, though the danger of hostile criticism may be averted by quoting the source of our information, but if, instead of this, we come forward and make positive assertions then we must expect to be controverted.

The discoveries of the Lake Superior iron ranges in Minnesota, Wisconsin and Michigan were usually the result of a fortunate combination of circumstances, but, when once these were established, it was comparatively an easy task for one who was well acquainted with them to determine that the Animikie rock series north of the international boundary was indentical with the formation on the above-mentioned ranges. Indeed, the rocks in which iron ore occurs were readily recognized, but it was a more difficult matter to determine whether iron deposits did actually exist in them. It required a long and tedious study of the geological, petrographical and chemical conditions which have been active here, and these had to be viewed in the light of experience gained on the other ranges. Having done this, and treating the different indications and traces found here as part of a complete system, I finally was forced to conclude that iron ore exists on the Ontario side of the line under the same conditions as in the Mesaba and other ranges. These researches and the minute examination of rocks, ores, diamond-drill cores, and rock sections, made me at last so familiar with the formation that I am confident of now being able to give close and accurate descriptions of the appearance of the minerals in the field, and present a reasonable account as to what their origin must have been.

In my treatment of the genesis of the iron ore deposits, I have departed from the well beaten path, over which for long years a number of chemical reactions and physical phenomena have been carried, and I have taken another route, which may appear too rugged and difficult for many to follow me, but I leave it to time to make the way more smooth, and trust that, with here and there an improvement, I may have pointed out the road to a clearer recognition of the forces that went to the formation of our iron ore deposits.

I devote considerable space to the geology of this region, a course which seems to me indispensable, not only because of the somewhat different classification of the series by Canadian and United States geologists, but also because it will tend to make more readily intelligible some of my hypotheses as to the origin of certain of the rocks of which I treat in this paper.

A NEW IRON RANGE.

Notwithstanding the fact that the bibliography on the iron ore deposits in the vicinity of Lake Superior is quite voluminous, a new contribution to this literature, treating of a newly discovered territory or iron range, should prove of considerable interest to those who, from a scientific or a commercial standpoint, are concerned in the finding and development of new and large bodies of high-grade iron ore, including not only the iron masters, but also geologists and mining engineers. It is perhaps hardly necessary to emphasize why these should be interested, for not only will there be in all probability fresh problems in geology to be solved, new mines to be opened up and more deposits to be revealed, but also we all know that of the merchantable iron ore at present known, at least 99 p.c. is in the hands of one company, upon which thus depend all other concerns interested in the smelting or selling of this mineral. We know also that the quantity of ore of Bessemer quality in sight is limited, considering the proportions which the iron industry, on the northern portion of this continent alone, has attained during the last few years. Furthermore we know that we are already mining and using ores of much lower grade than the Bessemer limit formerly demanded, and the use of these will grow in proportion as the supply of the higher grades still existing diminishes in quantity, and prices are raised. There will come a time when iron production will become more expensive through the adoption of different methods of smelting and reducing these ores, and those companies who are fortunate enough to be in possession of large bodies of high grade ores will have a vast advantage over those who are compelled to change their present mode of working. To all concerned, therefore, it would be an inestimable boon if there should be discovered another iron range near the shore of Lake Superior of as great an extent, if not greater than the Mesaba or any other Lake Superior iron range.

The new range alluded to has, so far as it has been examined, a length of over 25 miles, with an average width of about 6 miles, and lies between Gunflint Lake, the western starting place, and Whitefish Lake, the eastern terminus, while it is roughly bounded on the north by the Duluth extension of the Canadian Northern Railway, and on the south by the international boundary line west of Port Arthur. Although it is known that the iron-bearing rocks are found over a much larger area than this, it has not yet been determined whether that area which lies outside the above mentioned limits is not too near the margin of the formation.

It is indeed remarkable that most of the writers on the iron ore deposits of Minnesota have never mentioned, or only in an "en passant" manner, that the same iron bearing rocks extend into Canada. There is a brief notice to that effect in Prof. Van Hise's monograph, "The Iron Ore Deposits of the Lake Superior Region," but we poor mortals on this side of the line can gather very little consolation from his remarks. I hope not to transgress too much upon the patience of the reader if I make a few comments on the notes of Mr. Van Hise. My excuse must be that it has of late been an only too frequent occurrence for me to hear depreciating utterances, the direct sequel of Mr. Van Hise's expressed views concerning that part of our country which is my present subject.

He says:—

(1) "With one possible qualification, as far as one can see, there is no known geological cause why iron ore should not extensively exist on the Canadian side of Lake Superior. This qualification is due to glacial erosion"

(2) "In this paper it has plainly appeared that the iron ore deposits are products of the surficial belt, and that they were formed mainly in pre-glacial time."

(3) "It has also been seen, (pp. 334-336), that glacial erosion, which removed a considerable portion of the belt of weathering, certainly carried away large quantities of this iron ore, which have not been appreciably replaced by the processes of concentration since glacial time."

(4) "The United States side of the boundary is a region of moderately vigorous glacial erosion and very marked glacial deposition. The region on the Canadian side of the boundary, north of Lake Superior, is one of very vigorous glacial erosion and comparatively small glacial deposition." And again: "However, it cannot be doubted that the glacial erosion was more vigorous north of Lake Superior than to the south."

(5) "In so far as the glacial erosion was more vigorous, just to that extent more iron ore was lost north than south of the lake, and the conditions are to that extent less favorable for the existence of numerous large ore deposits."

(6) "The weight that must be given to this qualification can only be ascertained after extended exploration. Certainly it appears that the rocks in the Animikie area between Gunflint Lake and Port Arthur contain more of the original iron-bearing carbonate and show less of the residual material of the belt of weathering, viz. ferruginous slate, ferruginous chert and ore-bodies, these appear to have been largely swept away, thus exposing the little altered rocks. If in the Mesaba district glacial erosion had cut 150 feet deeper than it did, the larger portion of the ore deposits would have been lost. Moreover, the Gunflint formation of the Animikie district is not nearly so thick as the Biwabik formation of the Mesaba district. It may therefore be doubted whether the Animikie district will ever be so productive in iron ore as the Mesaba district."

This is the position assumed by Prof. Van Hise in the matter. In reply to his arguments let me say:

(1) Mr. Van Hise's hypothesis as to the role played by glacial action is doubtless exaggerated, as far as it is applied to the subject of his monograph, and more particularly as regards the denudation of the iron deposits in our country. This I shall prove more fully below.

(2) That the iron ore deposits are products of the surficial belt will hardly hold good, after a careful field and mine study, as will be seen when my argument is further developed.

(3) Everyone who is acquainted with the formation knows that most of the iron deposits of the Mesaba range are truncated by erosion and glacial action, and besides this we must take into consideration that these iron-bearing rocks have been most probably overlaid by Keewenawan rocks and doubtless also by trap overflows. I therefore fail to see how it is possible to reconcile the statement of Mr. Van Hise that "only a moderately vigorous" glacial erosion has taken place,

with the previous assertion that glacial erosion has carried away a considerable portion of the belt of weathering.

(4) In an examination of the Animikie district north of the United States boundary, we find that large areas of the iron-bearing rocks are still overlaid with diabase sheets, sometimes of considerable thickness, which have protected completely the underlying Animikie rocks, and that, from the time that the trap rock was laid down, no weathering has been possible at the surface of the iron-bearing rocks. Even in such places as have been denuded of this protection, the moving ice has caused but little loss, as in such areas we still see the Animikie rocks almost intact. Consequently we may safely conclude that the effect of the glacial erosion has been far less intense on this side of the line than is claimed by Mr. Van Hise. Why indeed should an imaginary boundary line have been proved such a barrier to the ice sheets, as to lead us to suppose that in Canada they played such havoc, while only a few miles to the south their action has been so considerate and gentle ? Nothing lay in their path to divert them to other quarters.

(5) This also shows that there is no foundation to his claim that we have, through this greater glacial erosion, lost more iron than has been lost south of the line. As a matter of fact I can say without any hesitation that not a pound of iron ore from our Animikie rocks has been lost or swept away, and, in direct contradiction to Mr. Hise's supposition, the iron deposits in our rocks should be larger and more numerous.

(6) In our iron ranges, as in all those in the vicinity of Lake Superior, exploration and exploitation are necessary for the verification of the existence and extent of the iron deposits, but surely it is not necessary to devote very minute and exhaustive field-studies to the task of proving that the original iron-bearing rocks, which interest us most at present, are still intact, and that they represent the *upper* and not, as Mr. Van Hise would have us believe, the *lowest* stratum. The "little-altered rock" alluded to by him as being exposed here, is neither the lowest horizon of the iron-bearing rocks, nor is it the same which he believes to be the floor of the iron deposits in the Mesaba. By

this time I presume, Mr. Van Hise has become aware of the fact that his latter theory, concerning the floor of the Mesaba deposits, is also incorrect, and that the true floor lies deeper, and consists of an entirely different rock. This theory has deceived the miners and drillers on that range to such a degree that, whenever they encountered at a certain depth a "horse" or stratum of "jaspilite" they stopped work, while, had they kept on, they would have found the condition for the existence of ore as favorable below these jaspilite sheets as above them.

And, if in some places our district does not show so much residual material, the fact can be explained in the same way, though in most localities this material is not by any means lacking. In fact in one place we had to use over 200 feet of stand-pipe, while in others much less was required. This residual material is derived from the rock which forms the northern margin, where it has been rather shallow but widely distributed throughout the whole Thunder Bay district. These thin rock-layers contained some high grade ore, but in small streaks, changed by the heat of the trap overflow from a limonite or hematite into a magnetite of high Bessemer grade.

I further dispute the statement that the Gunflint formation of the Animikie district was not nearly so thick as the Biwabik formation of the Mesaba district. Had Mr. Van Hise confined his claim to the immediate vicinity of Gunflint Lake, his contention might have been correct ,because, at its north and east extremity, the Biwabik formation is almost wholly cut out by younger eruptive rocks, as gabbro, granite and different trap rocks—porphyritic and graphitic diabases—as is also the case at the southern and western part of the same formation. But if he had examined the region eastward from Gunflint, he would have found that the Animikie rocks are perhaps considerably thicker than the Mesaba.

I am therefore compelled to conclude that Mr. Van Hise was not correctly informed, and is therefore not in a position to form an opinion as to whether or not these rocks on our side of the line will ever be so productive as the Mesaba.

As a matter of fact, for which I can vouch from personal observation, we have found iron ore in widely separated localities in the Animikie rocks, to what extent we shall soon learn from practical experience with the diamond drills, which we now have working there. I see no good reason why we should not open up here deposits of hematite ore as large and extensive as those of the Mesaba, Gobebic and Vermillion ranges, considering that the geological and petrographical conditions here are absolutely identical with those of the United States ranges, and that, as I have shown above, glacial erosion has not played the destructive role attributed to it by Mr. Van Hise, whose statement, that we have lost, more or less in their entirety, the hematite deposits formerly existing here, is so evidently erroneous.

I must once more emphasize the fact that these iron-bearing rocks are still intact on this side of the line, and especially those portions which, on account of their greater tickness, hold out promise of containing the largest deposits or ore.

These ferruginous cherts, or iron-bearing rocks, as we might continue to call them, were widely distributed over the archaean rocks, south, north and west of the present Lake Superior basin; not of course, everywhere to the same thickness, but principally in regions where the archaean granites had remelted the older schists. Accordingly we find to-day, these iron-bearing rocks resting upon and filling out every elevation or depression in the former. That these silicious rocks keep so close company with the older acid rocks is significant as to their genetic relation to the latter. In the more elevated portions of the granite, which would be along the present north shore of Lake Superior, and the region north of the Duluth extension of the Canadian Northern Railway, the deposited chert would be thin, and thinned out altogether where the elevation was more than 1,400 to 1,500 feet above sea-level. That these figures are correct, can be proved by field study in many places where the cherts have been protected by trap overflows; in a few other places, where the latter rock is eroded, black slates still cover them, but in general, those black slates are an insecure basis of proof, occurring, as they do, only locally and not over the whole chert area. Of these thin chert layers a large portion is eroded and carried into the depression southwards. The thickest portion of the chert is south of the above mentioned region, towards the United States boundary, where it rests in a basin to a thickness of several thousand feet. This basin rises rather abruptly near the other side of the boundary line, but through its whole extent the iron-bearing rocks are absolutely intact, and only a very few feet have been carried away in glacial times. It is easy to recognize which is the uppermost part of these rocks, because below the trap the chert has been melted, usually into a red jasper, which shows a "geflossene" structure, sometimes with the most beautiful arabesques or other fantastic designs.

The late Dr. Selwyn, formerly director of the Canadian Geological Survey Department, estimated that in some localities the thickness of the Animikie rocks reach even as much as 12,000 feet. Although I might not go quite so far, yet there is no possible doubt that in some places this rock formation is considerably thicker than the Mesaba.

As above stated, the present depressions in our Animikie rocks are everywhere overlaid with a residual material, exactly in the same manner as in the Mesaba. This material, I may repeat, came from the northern margin of the iron-bearing rocks, and is usually deepest where the ice-sheets butted against a high, resisting hill, while upon the south side of such hills the deposits are shallower and the slope is not so precipitous as on the north.

Numerous dykes have cut the iron-bearing diabase, also gabbro and granite; but the two latter can be observed occurring more frequently in the vicinity of and east of Gunflint Lake. These intrusions served beneficially in two ways, first, in loosening the chert strata, and second, in forming troughs of impermeable rocks, which permitted the meteoric waters to enter more freely and remain longer in contact with the iron-bearing rocks, thereby allowing the chemical changes to be performed more rapidly and thoroughly.

Now, what are the constituents of these iron-bearing rocks? Siderite and a cherty, silicious substance, in layers, varying in proportion from one per cent. to almost pure siderite. These materials are always *mechanically mixed*, not *chemically combined*. Where the latter should happen to be the case, it is the result of metamorphism or contact metamorphism.

At this point I will repeat in a synoptical form the conclusions arrived at and explained at greater length above:

(1) That we have here in Canada the same iron-bearing rocks as exist in the Minnesota and other Lake Superior iron ranges.

(2) That this rock formation is as thick, if not thicker than in the other localities.

(3) That the conditions for the formation of iron ore deposits here are identical with those elsewhere.

(4) That there exists therefore no good and sufficient reason why there should not exist as large, if not larger, iron deposits here as in the Mesaba or other districts.

GENESIS OF THE ANIMIKIE IRON-BEARING ROCKS.

Allusion was made above to the occurrence of an iron range in the Thunder Bay District, on the north-west shore of Lake Superior, similar to the Mesaba, and I expressed my confidence in the possibility of finding here as large, if not larger iron deposits than the latter. I will now devote some consideration to the genetic relation between these iron-bearing rocks and the rocks upon which they rest, and also to the relation in which the iron deposits stand to the rocks in which they occur.

In order to facilitate the correct understanding of the position I hold with regard to this subject, I shall divide this paper into the following heads:

I. Geology of the region.
II. Area upon which the iron-bearing rocks were laid down.
III. The constituents of these rocks.
IV. Their genetic relation to other rocks.
V. Their metamorphism and causes.

I.—*Geology of the region.*

Under this head I will describe the stratigraphical geology of that district where the iron-bearing, that is the Animikie rocks are found, and how they are produced, and to which era the different series belong.

I might mention, by way of introduction, that it will not prove a task of much difficulty to describe these various rocks as they are found here, that is laid down in their true sequence, but the most difficulty will be found in convincing the reader as to how they were produced, and under which geological period they must be classified, since, in regard to these points there exists such a divergence of opinion.

I shall therefore abstain from quoting the numerous written opinions on this subject, but shall consider principally those whose authors are intimately acquainted with the geology of our country, and whose writings have been founded upon personal observation and study. Not that I wish to belittle the opinions of other writers, but I believe that preference should be given to the version of those of us who have lived for years, and are still living among these rocks, and have devoted considerable time to their study, and endeavored to solve the mystery of their genesis. We also, being on the ground here, are naturally in more favorable circumstances than those who reside in localities where this rock formation is less fully exposed for study and whose theories on this subject must therefore always be to some extent speculative. Our earliest writers on this subject labored under the disadvantage of having to cope with a country, new, uncultivated, undeveloped and overgrown with a dense vegetation, through which the trails followed by the white or Indian trapper, and the waterways travelled by their canoes, were the only paths then open. These early pioneers of science could only obtain very fragmentary knowledge of the country, and lacked the means to weld it into an harmonious whole.

Even at the time of my own arrival, 15 years ago, there were many localities where no white man had ever set foot. All this is changed. Large clearings have been made for mining and agriculture, and still greater areas have been cleared by fires, which for years have swept the district, destroying not only the vegetation, but even the humus which covered the rocks, leaving them in many places absolutely barren. What does all this reveal to us? The plainest picture of the early history of our globe to Cambrian (?) times, and what we learn to read from this is expressed in a few words: "That the Laurentian gneisses and granites are not the oldest rocks of the crust of our globe, but that they form the base for the most ancient rocks—our schists—and that both are overlaid by pre-Cambrian sediments and divers eruptives."

I give them in tabulated form below, but I might first mention that there are some divergences between the Canadian classification and that of the United States Geological Survey. I therefore tabulate them both here, and shall speak later on their differences.

CANADA.

Archean.

ARCHEAN.	Huronian.	(Upper division) KEEWATIN (Basic)	Chlorite schists. Hornblende " Felsite " Sericite " Altered trap and quartz porphyries.
		(Lower division) COUTCHICHING (Acid)	Mica schist and finely laminated gneiss.
	Laurentian.	(More basic) LAURENTIAN (More acid)	Hornblende granite. Gneiss and hornblende syenite gneiss. Biotite, granite-gneiss (granitoid) and granite.
	Cambrian.	(Animikie) (lower)	Flat bedded cherts, carbonaceous argillites (?)
		CAMBRIAN Nepigon (upper)	Dolomite, sandstone, with intrusions of gabbro granite, trap in dykes and sheets.

UNITED STATES.

Archean

Granite and Gneiss.
Pre-Cambrian, Algonkian.
Huronian (principally sedimentary) * including the iron bearing rocks like our Animikie, further, quartzites and the folded schists of Canada (!)

KEEWENAWAN.

Trap sheets and sandstone.

(*NOTE.—As the list of Huronian rock names is too long and the same rock is often given half a dozen different names, also a number of them are claimed to belong to the Archean, it is most difficult to give these rocks in their true order.)

We see by this table that the Canadian Geological Survey has two divisions in the Archean series, an upper and lower, correctly so, while the United States Survey has only one, as far as it is possible to find anything amid this chaos of classification and names, viz.: the Laurentian granites and gneisses. Further the Canadians place the pre-Cambrian of the United States among the Cambrian; whether this is correct, is questionable. However, we might argue that when the United States place the oldest rocks of our globe among the sedimentary rocks, and appear to consider that they belong there, the Canadians have just as much right to classify the pre-Cambrian among the Cambrian, having the further justification that they believed that they had discovered fossils in these rocks. Let us now examine these classifications and commence our criticism with the United States method of classification of the Archean.

During the course of investigation in our field, and comparison with other localities on this and other continents, I am convinced that in no other country does there exist a more simple or plainer exposure of the oldest rocks that compose our earth's crust. This applies especially to the Laurentian series, which represent the greater portion of the rocks of the country. There is nothing to mar a clear view, or to prevent easy study, for no younger sedimentary rocks are overlying them, at least not in sufficient volume to prove a disturbing factor. Next in importance are the oldest of the rocks known to geologists, the metamorphic schists, which are steeply tilted and quite crystalline. Were we to plat these rocks, they would form on our diagram large and long-drawn-out islands in an immense sea of Laurentian areas. Now as to the relation that these bear to each other. In brief, I may say that the Laurentian rocks form the base of the schists; whenever the latter are eroded we can see their imprint on the former. We further observe that they rest unconformably and sharply defined upon the gneisses and granites, but we also notice the latter rocks as dykes, intruding in great numbers into the the schist strata. These schists represent the remnants of the former crust of the earth, which was almost entirely remelted when the viscous Laurentian magma again became eruptive and fluid, broke up and absorbed this thick crust. Later on a more gentle flowing motion must have prevailed, through the influence of which this magma "underflowed" the older rocks that were still remaining, melted grooves and channels on their lower side or base, leaving the projections protruding downwards like knife-blades or stalactites, into the magma, as we find them now bedded into the solidified gneises. In the course of ages, portions of the schist have been eroded, the glaciers sweeping away the residua and polishing the surface of the gneisses, so that we see remnants of the schist still resting in alignment with the foliation of the gneiss. In certain places, where these softer remnants were more completely eroded out of their harder resting place, the surface of the gneiss has the appearance of filigree work. That the schist-remnants, resting in the gneiss, usually appear in line with the foliation of the gneiss, is perhaps a certain indication of the occurrence of the flowing motion, mentioned above, of the latter in a certain direction. A further confirmation of this is given by the arrangement of the mica, mostly biotite, which, it seems probable, in the last stage of the flowing movement of the gneissic magma, had already crystallized out of the mass, and the different particles arranged themselves so as to follow each other along the line of the least resistance. This arrangement in many cases gives these rocks a foliated appearance which is however only an optical illusion. The gneisses are only really foliated, or appears chistose, or show tectonic metamorphism, in places where they were disturbed by the younger eruptive rocks or came in contact with them.

Without going into a detailed description of the petrography of these old Laurentian rocks, for which I refer the reader to the reports of the Canadian Geological Survey, especially to Dr. A. C. Lawson's report for 1887, Part F, I might merely mention that they consist in part of basic rocks,—of hornblende granite and hornblende syenite-gneisses,—and in part of acidic rocks,—of biotite gneiss and biotite granite-gneiss. One peculiarity of the distribution of these gneisses is that usually the more basic is found in the neighborhood of the more basic series of the old Huronian, the Keewatin hornblende schists, while the more acid, very frequently, but not invariably, is found in the neighborhood of the more acid series of the Huronian, the Coutchiching mica schists. I mentioned above that, through the arrangement of the particles of the dark biotite it is often difficult to distinguish between them and the really foliated gneiss and it would be a hard matter to prove that they were not one and the same rock and not of idiogenetic occurrence. The same may be said of al lthe Laurentian gneisses, for they merge imperceptibly into one another. In many places we observe intrusions, larger or smaller, of a younger granite, either as dykes, apophyses or large circular or elliptical areas, which are often mistakenly classed as belonging to this same early period. These granites, although sometimes also gneissoid, followed a period of basic eruptives, such as gabbros, diorites, and peridotites, with which in some localities they are found in close connection, even intruding into them, and they are therefore younger. A further proof that these granites are a more recent formation, is the fact that they often contain large angular inclusions of gneiss, sometimes ten to fifteen feet in length, on the top of hills hundreds of feet above the level of the gneiss.

Very frequently we find fragments of the old Huronian rocks, either angular or rounded by melting, resting in the gneisses, usually at no great distance from the contact with the former, though these are also occasionally observed removed some distance from the point where they dropped into the gneissic magma. For further information on this occurrence, I again refer to Dr. Lawson's report cited above.

The brief description of the old Laurentian rocks given here, together with reference to the sources given for more detailed information, will or should convince even the strongest adherent of the sedimentary origin of these gneisses that there is no truer igneous rock in existence than our Laurentian gneiss, and they are also found in other regions occurring exactly as they do here, whether they are obscured or not, covered by younger sedimentary deposits, or metamorphosed through one cause or another. In the following pages we will have still further proof of their origin, and see what light they throw upon the oldest rocks of the earth's crust.

Geikie, in his Text-book of Geology, page 1156, asks, "whether these gneisses were ever connected with any superficial volcanic activity, although no such connection had yet been ascertained, but it might be regarded as highly probable." In my opinion, volcanic activity, in the sense of a lava or magma extruding from the vent of a volcano, was not necessary, or possible, for the largest portion of the crust was remelted, and there was nothing therefore to confine the gases, fumes and lava, and to compel them to seek, perforce, an artificial outlet. The later granites, on the other hand, show at many places signs of volcanic activity. Some of these volcanoes show different emanations at different periods, as in one a granite, in another a gabbro and again in another an acid rock, and so on. These successions of basic and acidic rocks seem to have been the rule during the earliest history of our globe, this phenomenon being plainly seen all over the country. The sequence has been :

(1) First crust, (I should have said the first of which we have any knowledge), Basic ; our Huronian rocks.

(2) Second crust and intrusions into No. 1, Acid, Laurentian rocks.

(3) Third eruptions and intrusions, Basic ; Gabbro, Diorites, Peridotites and Traps, not specially classed, usually wrongly grouped with No. 1.

(4) Fourth eruptions and intrusions, Acid ; Granite often wrongly classed with No. 2.

(5) Fifth eruptions and intrusions, Basic ; Diabases, porphyritic, graphitic, amygdaloidal and typical.

When the Laurentian gneisses and granites began to solidify, they contracted, and in consequence the overlying, older rocks, being forced to follow their movements, were steeply tilted and compressed, this giving them their slated, foliated and crushed appearance, and naturally furthering their metamorphism. A number of writers claim to recognize in this slating and foliation, a proof of the sedimentary origin of these rocks, but I am convinced that their view is erroneous, for when we consider the facts as set forth above, deduced from the clearest field evidence, the only possible conclusion is, that these rocks are the result of the cooled magma which surrounded our globe in the earliest stages of solidification. It were unwise to affirm that this was the first crust of all, for there may have existed many crusts long previous to this which have suffered the same fate as did the one which we are considering, through the eruption of the granites and gneisses, but so much more thoroughly as not to leave a trace behind. Where, indeed, could these sediments have come from? When we realize that these rocks themselves were resting upon an exceedingly hot, viscous magma, would it have been possible to float a sediment with water on top of this fiery, molten mass? Where could the water have come from in sufficient quantity to carry out this process? At that time water could only have existed in the immediate proximity of our globe in the form of vapor, and, even if such vapors should have become condensed on the outer sphere, the resultant water could not have reached the surface as such, for the heat radiation would be too great for such condensation, and would have made absolutely impossible any accumulation of masses of water upon the surface. There is no basis for the hypothesis that the Huronian rocks are the product of sedimentation, their foliation and schistosity forming no argument in favor of such a theory, these being matters of every-day observation in even the most solid eruptive rocks, wherever they have been subjected to the same stresses as have produced this appearance in these Huronian rocks.

This being the case, the practice adopted by the United States Geological Survey of classifying these Huronian rocks of ours among the sedimentary and Pre-Cambrian, is without doubt peculiarly erroneous, and I do not see any justification for casting ridicule upon our own classification, which groups them among the Archaean, and calls them the oldest ones of that series. Everyone knows that the name, Huronian, was applied by Logan to the rocks occurring on the north shore of Lake Huron; granting that a large portion of these are sedimentary, we are also well aware that the older metamorphic schists are not lacking there, and if we further consider that these latter rocks are the dominant representatives of their class in western Ontario, while the younger sedimentary rocks show only in isolated areas, why are we not justified in giving the former this specific name? Our practice has far greater right and correctness than that of the United States, which names as Huronian what is not Huronian, as for instance the Animikie series, which does not exist round Lake Huron; still in all monographs on the Lake Superior iron region we see them classed among the Huronian, and the same rock is given possibly a dozen different names. Also among their Huronian rocks appear the Canadian folded schists, which means that they are—horribile dictu—considered sedimentary!

If the Canadian Geological Survey classifies the Animikie as lower Cambrian, this should fit in with the hypothesis of the American geologists, who claim that a number of the minerals in these rocks, carbonate of iron, lime and magnesia, owed their origin to the presence of life in this primordial ocean. (I shall discuss this furthur below.) Should this be correct, I see no good reason for us coining a new period, "Pre-Cambrian," out of these rocks, when we know that the Cambrian age is the one in which we thought to have detected the first existence of organisms. There is doubtless a certain incongruity in the determination and classification adopted by the United States Geological Survey with regard to these, the oldest rocks of our crust. If we wish to adopt a new name for these rocks, then we have to do away with the organic life theory, and the quicker we do this the better, because it can not be supported by facts. The reason for this will follow hereafter.

Now if the placing of the Animikie rocks in a new geological era was incorrect on account of connecting them with organic life, then the Canadian classification is also incorrect, because we have no proof of animated organism existing at that time. Logan once found in a dolomite a peculiar design whose structure was somewhat similar to that of a foraminifer, at least Sir W. Dawson thought that he recognized it as such. This view was later disproved by a number of observers, but I think that the most effective argument in opposition to it is furnished by these rocks themselves, which have never yielded anything in corroboration of it, although they have been prospected and mined for years and eagerly and carefully scanned for traces of Logan and Dawson's "Eozoon." Can we conceive of the possibility of the existence of organic life, when we consider the origin of these rocks, which were laid down in a time of almost uninterrupted volcanic activity, during which there appeared, in the following order:—

First, the cherts and carbonate of iron, deposited by hot, mineral springs, and geysers.

Second followed the eruption and intrusion of gabbros, diorites, peridotites, traps, etc.

Third, took place the eruption and intrusion of granite.

Fourth, followed intermittingly, diabase eruptions and intrusions, and, in their last stage of eruption, overflows over the whole Cambrian area.

Fifth, might be mentioned the deposition of tuffs and ashes, from (4), which seem to have always preceded the extrusion of the trap magma.

When we see the great number of dykes and the crater-like structure of hills, both large and small, and the heavy overflow of trap magma, the deposition of which was distributed over a considerable period, we cannot help coming to the conclusion that it was utterly impossible for organic beings to have existed at that time. Therefore we have to exclude this hypothesis from our theory of the origin of the minerals occurring in these rock-formations, and also to dismiss the idea that the Logan "Eozoon" was an organism. This may be yet better recognized after following my views regarding the origin of the chert, slate, etc.

Following the sequence of these rocks as they were laid down, in an ascending order, we come now to the next rock above the granites and gneisses, which is a ferruginous chert, found compact, or as granules, varying in size from that of granulated sugar to that of a pin's head or even of a pea. If in the latter size, we often find the largest individual granules filled either with iron carbonate, or lined with whitish quartz in vug-like fashion. In color the chert is from white and yellowish grey to dark green and black. Always associated with it is siderite, sometimes intimately mixed, but more often surrounding the chert granules as a cement, also in separate independent layers, and again mixed with the cherty silica in almost every percentage. This variety of form, of mixture and of color, is so great that it alone would provide subject matter for a voluminous paper. Not infrequently we also meet with a red jasper associated with the chert, but this is, in most instances, if not invariably, produced through the heat of intrusive rocks, for we find this jasper principally in the neighborhood of these, and especially below the trap overflows, where it often shows a flowing structure in most beautiful designs.

As secondary minerals there appears here and there in small fissures, calcite, and in the vicinity of basic rock intrusions, some iron pyrites.

The thickness of the ferruginous chert rock may be estimated as being, in some places, 2,000 and possibly 3,000 feet, but not, as was taught some years ago, 12,000 feet. In most localities the thickness is not more than 500 to 1,000 feet.

As oxidation products of the ferruginous chert we find magnetite, in smaller or larger layers, but principally hematite, either in large, flat-lying beds below the drift, or in troughs of the rocks which form the base of the chert. The magnetite was formed from hematite, or limonite, by the heat of the intruded or overflowed rocks, by exclusion of air, and it occurs often very pure and of extremely high grade, which is characteristic of ore formed before the eruption of the various later rocks. Later I shall have more to say about these rocks and minerals.

Next in order would come the locally so-called black slates, also and perhaps misnamed Argillites resting conformably on the former. These rocks are, doubtless, the solidified beds of ashes and tuffs produced by explosions and exhalations, which formed the prelude to the trap eruptions in Pre-Cambrian, and possibly also in Post-Cambrian times. These slates are not found everywhere, and are in many places only very thin, in other places, and these are principally near the larger vents, they are thicker, but seldom more than 300 to 400 feet. Their aspect in some localities is quite black, in others from light to dark grey in color, if so they have the same shade of color as the diabase covering them; they are in some places foliated, but are too soft, that is, not strong and elastic enough for roofing slates but have the tendency to break in cubes; in other places they are compact and have only a faint foliated aspect. The black color in the darkest variety is produced partly by iron and partly by graphite. Some writers present this graphite as evidence of the existence of organic life in that "primordial sea." I think that I have already given sufficient proof that this can not be the case. We have to look for another source, and this source is found in a number of trap dykes, which are intimately and heavily mixed with graphite. In examining these closely we find that they are plutonic rocks of coarse crystalline structure, and exposed to the surface through the erosion of the chert and later trap overflows, so that there can be no question of an infiltration of carbonaceous matter in solution. Upon observing this graphite in the trap, by a natural inference one would be led to consider whether it would not be just as possible for the graphite in these slates to be an emanation product of the trap volcanoes as the black slates themselves. If it was possible for the graphite to be sent forth in a magma stream, then it should be no impossibility for it also to have been mixed and thrown out with the ashes and tuffs coming from the same source. With our present knowledge of volcanoes and volcanic phenomena, it surely should no longer be necessary to connect every little particle of carbonaceous (in this case, graphitic) matter with organic life; how many are the tests that have been made from the gas exhalations of volcanoes; how often is graphite found in eruptive rocks, under conditions that preclude the possibility of organic origin; why then jump to conclusions which are applicable under no circumstances, and least of all in this case? Surely it would be outside the bounds of reasonable speculation to affirm the theory that all the carbon gases which our globe contained during the earliest periods of its history were ejected into space, and that from this space the later-appearing organic life had received its carbon compounds, and that again these organisms had furnished the carbon for inorganic substances, such as minerals and rocks. From whence then these graphite contents in plutonic rocks, these diamonds in igneous basic rocks, whence the carbonic acid and oxide gases in the exhalations of volcanoes and in the pores of igneous acid rocks? Moreover, if we believe that other worlds are composed of the same material as ours, from what source did the carbon in meteorites come, as an alloy of iron and nickel? Surely nobody will claim that these are composed of a mixture of metals and organic remnants. All the examples cited above should lead us to regard the origin of the graphite in these slates to be different to what has been supposed by some writers, nor should we apply that easy, less mentally exciting method, the organic theory, more especially when we are dealing with a geological period which was a time of almost uninterupted volcanic activity. Yet further, if we are doing away with the organic-life theory altogether, we shall have to consider the origin of the calcite also, in these black slates, from a somewhat different point of view to that taken by these other writers.

Silver mining in the black slates has furnished us with the clearest evidence as to the origin of the calcite. Wherever we mined in the neighborhood of, or alongside a trap dyke, the veins were not only stronger but also better—in fact, I might say in most instances, only at such places—mineralized with argentite and native silver, sphalerite, chalcopyrite and galenite, and with rock minerals, principally calcite, also fluorite and barite, with only here and there some quartz, which appeared, in most cases as a secondary product. At greater distances from the dykes the veins carried only the rock minerals. Fumaroles alongside the trap were evidently the direct cause of the filling of these veins, for even at the present time warm mineral springs were tapped in the lower mine workings, along the dykes. Of these the Silver Islet spring was especially noteworthy, also those in Crooks township and Medicine Bluff, all of which are quite saline in character. The Silver Islet spring was tapped at a depth far below the level of the slates and cherts, therefore the lime contents of these waters could not have their origin in the latter rocks, as might be inferred from Bulletin VI.

Minnesota Geological Survey, p. 145. That these lime waters intruded also into other rocks, that is in the planes of the slates and small fissures of the cherts, is easily understood, and may likewise be recognized by examining the drill-cores coming from every depth of the formation. Originally, these slates may have been free from lime, and so most assuredly must have been the cherts, as can be sufficiently proved at places where the lime water had no admittance into them. If the lime had been produced in a manner similar to what some have taught us, we would see the calcite not only filling the interstices of the rock, but we would find an intimate mixture of lime with the other rock constituents. More than this, we would not see an exclusively coarse, crystalline vein product, but rather a fine-grained or crypto-crystalline, almost amorphous looking lime rock, such as we see in the younger sedimentary and fossil limestones. And we would, further, not only find large, true fissure veins, of considerable width and strike, compactly filled, but we would also notice in the slates and cherts lime rock layers, especially at places where there were no rock fissures to be filled. Instead of this we see, even in the highest elevations of this region, immense calcite veins in localities where there are no slates and very little chert, but only granite and trap, and where a draining process into fissures, from the directions in which slates are resting, was an impossibility. And why should the metallic minerals have kept so closely in company with these trap dykes, if they were not brought up by the fumes and vapors escaping from a cooling magma, or even from a deeper source? These, reaching the upper strata of the earth's crust, mingled with the waters flowing into those wide fault-fissures of the Animikie rocks, and, being forced upwards by the difference in the isogeotherms, the minerals were deposited in the cooler rock strata, in the slates first, and later in the cherts and granites, according to the shifting of the isogeotherms downwards. I might yet mention that we find these calcite veins almost exclusively below the last trap overflows, and only in a very few places do we find small stringers of calcite, fluorite and amethystine quartz filling little fissures at the surface of trap deposits, which gives us proof that the thermal waters above described had force enough to reach even the highest points of these hills.

After the period of the deposition of the Animikie rocks the lake in which the former were laid down must have subsided before the filling of these calcite veins, for it would otherwise have been impossible for these veins to have been formed in the manner in which they were evidently produced. The subsidence of these lake waters from over the largest portion of the former lake area is easily understood, when we see the filling up of the lake bottom by sedimentary as well as eruptive rocks, and take into consideration the sinking of the present Lake Superior basin, which occurred very likely after the principal trap eruptions.

Whether the upper part of our so-called Cambrian rocks, the Nepigon or Keewenawan series, were laid down in that same lake before the subsidence of its waters, or whether they date from a later period, after the waters had refilled that part in which they were laid down, is a matter rather difficult to substantiate, for these rocks do not occur everywhere over the Pre-Cambrian rock area, but only in the extreme eastern portion of Thunder Bay district; it seems to me however that the latter hypothesis is the more probable, for these Nepigon rocks rest unconformably upon the Animikie, and the material of which they have been composed must have been derived from a totally different source to the material that forms their close surroundings; it came possibly from the north-east and from the same sources that have contributed to the rocks upon the north shore of Lake Huron or in Eastern Algoma, with which the Nepigon rocks are doubtless identical. One exception is found here in the sheets of amygdaloidal trap.

Before I commence enumerating the different rocks of the Nepigon series, I have to speak shortly of the numerous intrusions of eruptive rocks in the strata of the Animikie series. The first to make its appearance was a gabbro, the next a granite, which is usually found in close company with the former, and the third, a diabase, which was especially voluminous at different periods and, very likely on account of its very fluid condition, not only formed dykes, but also intruded as sheets and laccolites between the slate strata, and finally flowed in considerable masses over the top of the whole Pre-Cambrian rock formation, solidifying there in columnar form. On the north shore of

Lake Superior, especially at Nepigon Bay, several sheets of amygdaloidal trap are found below and between the sand stones which are the northern margin of a great number of such sheets passing through Lake Superior, coming up on Isle Royale, dipping into the water again and re-appearing to the southon Keewenawan Point. These trap sheets contain some native copper.

I come now to the upper Pre-Cambrian rock series, consisting of:

First, a jasper and quartz conglomerate, resting unconformably on the slates, being 4 to 5 feet in thickness.

Second, a sandstone followed by a dolomite, or more often in alternating layers with the sandstone, which is sometimes of grey or reddish color; the same variety of color prevails in the marl. Here and there we also find in these rocks intrusions of trap, but the principal mass of the latter rock rests, as I have repeatedly mentioned above, on the top of the whole series of Pre-Cambrian rocks, and is therefore the youngest member of this, or of any other formation in this country. I must not forget to make mention of another conglomerate, a boulder and pebble conglomerate in which the cement was a trap lava, seemingly of the same age as the last trap eruption, and occurring only at a few places near the north shore of Lake Superior. The thickness of the various Nepigon rocks is as follows:

Jasper-conglomerate, 4 to 5 feet.

Sandstone and marl, 200 to 300 feet.

Trap overflow, over the whole, 200 to 300 feet.

The upper series of the Pre-Cambrian rocks is, like the lower, absolutely free from fossils; in vain have we searched for even the smallest trace, but have not so far been fortunate enough to verify Logan's find, although we have actually been working under more favorable conditions than he, being able to see the rocks, not only more exposed, but also more opened up by mining operations. Over and over again prospectors have brought in pieces of float limestone containing fossils, but in every instance these proved to be strangers to this district, and came with the ice from northern regions.

I considered it necessary to make this long digression into the geology and petrography of this district in order to make the subjects that I next deal with better understood, that is to give a key better fitted for the solution of the problem of the origin of the iron-bearing rocks and also of the iron deposits themselves that occur therein. A still further reason was the divergence of opinion that exists between the Canadian and the United States Geological Surveys in respect to the classification of these oldest Archaean and Pre-Cambrian rocks, so that I felt the necessity of treating this subject at somewhat greater length than was my first intention. If, however, in the foregoing pages I have offered anything which might tend to bring both sides and their views into harmony, I shall rejoice to think that my efforts, which were perforce curtailed by lack of space in the limits of a short essay, have not been in vain.

II.—*Area upon which the Iron-bearing rocks were laid down.*

The area upon which the iron bearing rocks were laid down must have been considerably larger than that which Lake Superior now occupies. This area was most extensive towards the south, west and also north-east, but probably did not extend far to the east, where the margin seems to be reached not farther than longitude 86° 30′, for we find here numerous remnants which were protected by our Nepigon rock series (Keewenawan), and which show the cherts in that region to be only a few feet in thickness, resting upon Archaean schists in close proximity to the Archaean granite. Near Thunder Bay they do not extend farther than 10 miles north of Port Arthur; this margin can be followed in a nearly straight south-westerly course, skirts the Giant's range to the south, and reaches its extreme westerly limit about 93° 30′ longitude, while its southern limit is not far over 46° latitude. This area formed a basin, but where its deepest part was situated is obscured through the further sinking of the present Lake Superior floor, which must have occurred at the time of the trap eruption. The extreme margin of the iron-bearing rocks was always at an elevation of 1,400 to 1,500 feet above the sea level, as we can see at numerous places where they were protected by trap overflows or sedimentary rocks of the Nepigon series.

It is hardly necessary to affirm that this basin was filled with water, and was therefore a lake of considerable size and depth. If we consider that this water was resting in a syncline in the Laurentian granite and gneiss, and it was therefore on a heat-radiating rock surface, it must doubtless have been warm, or even hot.

III.—*The constituents of these rocks.*

It will be easily understood that for long periods after the solidification of the granites, a fumarotic and geyser-like activity must have existed, and that the contents of these volcanic springs were laid down in the bottom of that lake as an amorphous silica, and the iron precipitated as a carbonate. They were formed into concretionary sediments, and exhibit all the forms of geyserite and hyalite, or present a pisolitic structure, the latter form predominating, as can be plainly noticed if the ground mass, or cementing mass,—usually siderite—becomes soft or oxidizes; after breaking the rock we have an oolitic picture, the little granules remaining whole, so that some of them, consisting principally of ferric oxide and silica, can be lifted out of their resting places with a pair of fine tweezers. Both the siderite and silica appear very unevenly distributed throughout the whole formation, sometimes the one and sometimes the other predominating. This might have been caused, first, partly by an uneven production; secondly, partly by the pressure of the geysers, whereby a violent movement of the waters was produced; thirdly, by a wave-like movement of the water, compelling the lighter particles to follow these different motions. Hardly any other way is conceivable by which these ferruginous cherts could have been laid down, as I have mentioned above, than by "volcanic springs," perhaps principally in geyser-like form. If they were sediments, carried there by water-courses, we should find different rock minerals mixed with them, but this is not the case. This occurred only in the last stages of the production of the chert deposits, when the material for the black slates was laid upon the top of them. Geysers of hot silicious solutions, containing more or less iron, very readily suggest themselves, when we see the many remnants of old geyser vents in this country, of which one stands out as especially remarkable and in an excellent state of preservation. To-day we still see its walls as perfect and smooth as if its activity had ceased only a short period ago. And geysers and the action of geysers should surely be nothing remarkable in the early history of our globe ; how many localities show signs of them and how many are still in activity ? Let us look at the action of the geysers which silicified those Arizona forest giants into the most beautifully agatized and jasperized wood, or of those at Yellowstone Park. Although the latter cannot be compared in age with the former, I do not see any good reason why, in the earliest history of our globe, similar phenomena should not have occurred, especially so shortly after those immense changes in our earth's crust had taken place, that is, at a time when the Laurentian granites became eruptive, the larger portion of the former crust was remelted, solidified and contracted and sent forth from its magma hot gases and fumes for long periods thereafter. These came into contact with the surface waters, percolating or even flowing through the larger and smaller fissures of these rocks, which took up the contents of these gases, or even the differentiated silica, or dissolved the silicious contents of the granite. Naturally in this case we have to reject the idea of capillary percolation, because the heat in the rock would have been too great to permit a capillary descension of water. At shallow depths these waters would have been rejected in the form of steam, and fissures, produced by contraction, faulting or shearing, would give the meteoric waters an opportunity to flow in, and they would be again ejected in a similar pulsating manner, according to the shifting of the isogeotherms downwards, as is the case with the Yellowstone or Icelandic geysers to-day. As a further proof that the water in this lake was hot may be cited the total absence of even the lowest form of animal or plant life. The fallacy of Sir William Logan's discovery of the "Eozoon" in the black slates or Dolomite has been shown in the earlier portion of this paper.

I think that it would be merely carrying "owls to Athens" for me to adduce any more proof that the present iron-bearing rocks were laid down by numerous hot mineral springs in a lake or sea of considerable extent ; and their contents were derived from gases emanating through fissures and vents out of a cooling granite, and also partly from differentiating silica, as well as from parts of the same rock from which these waters dissolved the silica.

Considerable time must have elapsed from the beginning to the ending of the production of the ferruginous chert, after which followed the sedimentary deposition of the black slates, from ashes and tuffs of the trap volcanoes. These slates were seldom thicker than from 300 to 400 feet, and were succeeded by a quartz and jasper conglomerate of a thickness rarely over four feet. The next deposition was a dolomite or marl, interstratified with larger and smaller layers of sandstone, both together seldom over 200 feet thick. All these sediments must have been very unequally distributed over the chert area; in some parts they were very likely absent altogether. Judging by the occurrence of trap in other localities, this, the youngest rock in our country, must have been produced in post-Devonian times, after the deposition of all the sedimentary deposits, which it overflowed in varying thickness.

IV.—*Their genetic relation to other rocks.*

How much this thickess has been it is hard to say, for no other younger rock exists to tell us its whole history. We see only remnants left, of which the most voluminous is about 200 feet thick. Although we see the dykes of this rock in large numbers almost everywhere, it is very questionable, however, whether the emanating lava found a region level enough whereon to rest in an even thickness, also whether this lava was produced in the same volume by every dyke; this would, however, be impossible, for there are large and small dykes which must have varied greatly in their capacity for production. Exactly as we notice hills and dales today, so at that period there must have been elevations and depressions. It is hardly conceivable that erosion alone should have produced those existing at present, they were merely intensified by the scrubbing and grinding of the icebergs which freed the rocks from the eroded products. In our country this erosion was not vigorous enough to reach the iron-bearing rocks to such an extent as to give us cause today to mourn the loss either of our iron deposits nor yet of the material which would make further deposition possible, as has been sometimes argued.

V.—*Their metamorphism and causes.*

Now it will be seen from what I have stated here, that there were places, after the eruption of the trap, where the overlying material could have been no barrier to prevent these meteoric and mineral waters from percolating into these iron-bearing rocks, and producing such changes as would be necessary for the conversion of the ferruginous chert into iron ore.

Before I commence on my version of the genesis of these iron deposits, let me first recapitulate here what Mr. Van Hise says regarding the process that took place, which he sums up as follows:

(1) The principal part of the iron is derived from the belt of weathering, consisting of detrital ferruginous sandstone and conglomerate.

(2) To some extent also, it is derived from the oxidation of the iron carbonate in place.

(3) All the facts, however, lead irresistibly to the conclusion that the final and most important step in the production of ore bodies was secondary enrichment by downward percolating waters, below crests or slopes, where such waters were conveyed by the pitching troughs.

(4) Waters which followed the more circuitous route transported iron carbonate; waters more directly from the surface which did not pass through iron carbonate, bore oxygen; the two kinds of solution mingled and precipitated iron oxide. The waters ascended and escaped below the valleys, and finally the great quantity of water which was converged in these troughs and moved downward, abstracted the silica and carried it elsewhere.

Theories founded upon facts are incontestable, but the practice of modelling facts—nolens-volens—into the frame of a preconceived theory, antiquated or not, is dangerous, and only too often serves as a shelter to hide one's true conviction, for fear of criticism, just or unjust. Either we have to shelve a theory fearlessly if it is useless, or we have to remodel it so as to fit the facts. What about the above? Consideration of clause (4) alone would tear the fabric of this peculiar theory all to shreds. Imagine great quantities of water moving downwards, of course first through the belt of weathering, which is said to have furnished the principal source of the iron ore deposits, but not extracting any of the iron said to exist there, and leaving all the carbonate of iron in it, extracting only the silica and disappearing, trace-less, with this. Next comes a second inflow of water which extracts all the iron from this belt of weathering, and carries it into the spaces prepared for it by water No. 1; at the same time there comes, from another side, water No. 3 which, going through quite different channels and fissures, not detected by either water No. 1 nor 2, collects carbonic acid and carbonate of iron, then meeting water No. 2 exactly in those prepared spaces, frees it from the iron, which settles down in that water-filled trough, and waters No. 1 and No. 2 disappear behind the scene. Another peculiarity is that this same process must have been going on in all the ferruginous chert deposits around Lake Superior, in exactly the same manner, viz. in Mesaba, Vermillion, Gogebic, Menominee, Marquette and here, because the iron in all of them is derived from the same rock material.

Let us now dissect this whole process a little more in detail, and if the reader will take in hand Prof. Van Hise's Monograph on the iron ore deposits of Lake Superior, and will look at the sections of the mines and follow my comments, he will soon be able to judge whether Mr. Van Hise's theory is correct or not.

In the first place let me say that this ferruginous chert or iron-bearing rock is a very compact, and, owing to its constituents and structure, usually a very hard rock, and it was very little affected even by the many eruptive rocks, such as gabbro, granite and trap, for we see it seldom dipping more than 12 degrees, and in most cases but 5 degrees from the horizontal. Even in the neighborhood of these eruptives it was but little disturbed, and seldom showed large fissures through which great quantities of water could have rushed in. Perhaps we must except some fissures which were produced here and there at the time of the trap eruption, through faulting; these however were soon closed again by the fumaroles of this rock carrying in calcite, baryte, fluorite and amethystine quartz. Notwithstanding these considerable dynamic forces, the chert rock along the walls of these fault fissures is very little disturbed; the same may be observed in the Vermillion district, where a double folding of the formation occurred, but the position of the cherts is still nearly horizontal. Now these waters, in order to reach the cherts would have to pass throught the belt of weathering, and would have dissolved any iron in their path. The chert, as we already know, consists of a mechanical mixture of carbonate of iron and a cherty silica, consequuently, as soon as the water reached this carbonate of iron, the carbonic acid would have precipitated the iron out of such waters, the iron precipitates would have clogged up the interstices and capillaries of the chert, and the water would have been diverted elsewhere, and would never have reached the base of the chert, where we usually see the iron resting. Supposing that water No. 1 really had not dissolved any iron from the belt of weathering, but that it had actually found its way in and through the chert and had extracted the selica, would it not, at the same time, have dissolved the carbonate of iron, and would not both have left the troughs together? If so, then water No. 3 would have found neither carbonic acid nor carbonate of iron for precipitating the iron out of water No. 2, and the whole process would have been impossible, that is to say, we would find no iron deposits to-day. But why should only water No. 2 be able to dissolve iron from the weathered products, and why not also water No 1? Who can solve this riddle? Further, in looking at the sections of the troughs in which the iron deposits rest, we notice that the water had to ascend to a considerable height in order to escape again. If what Mr Van Hise claims is true, the hydrostatic pressure must have been equally considerable, and would it have been possible to deposit anything under such a pressure? And further, water that is standing in a basin or trough does not permit of the dissolution of any kind of rock, even under pressure, and if this rock was submerged, the water could not under the circumstances have dissolved the silica out of the chert.

I must repeat here that these Keewenawan sandstones, marls and conglomerates did not contain sufficient iron to make one decent iron ore deposit. These rocks can be seen here, in our country, under an overflow of trap, still intact, and their iron contents may be easily judged. Besides they were not deposited everywhere, and in many places only in shallow layers, therefore the belt of weathering has played a very subordinate role. Even supposing that there had been iron in considerable quantities in this belt, would not water No. 1 have leached every particle out of it, considering the length of time it must have taken to dissolve the silica out of the chert, transport it out of the troughs and make room for these large deposits of iron ore? Would not this light, floculant iron precipitate have suffered the same fate as the silica?

What I have said above will show that Van Hise's theory does not rest on a solid foundation, for the following reasons:

(1.) There was no belt of weathering which could have furnished sufficient iron for these masssive deposits.

(2.) Water that percolated through a ferruginous weathered rock material would dissolve the iron by the first contact and not after it had first done other work.

(3.) Water that flows down one slope and has to surmount another fills that space into which it flows, and is under static pressure, actuating a force that would not permit of any undisturbed precipitation and settling of light precipitates

(4.) Rock under water are not oxidized or markedly changed,

(5.) Water that dissolves hard chert rock also dissolves carbonate of iron mechanically mixed with it, and if the one is washed away the other has to follow.

(6.) There would not have been merely a sagging, (as Mr. Van Hise says) but a caving of the rock formation into the spaces from which the silica was eliminated.

At this point I may also mention that Mr. Spurr attributes the existence of the iron deposits to the oxidation of "Glauconite." I myself have not been able to detect this mineral in any of the cores or mines that I have examined, but there exists abundantly throughout the whole formation a green mineral and a skeleton of siderite, and in some instances also quartz, both surrounded by hematite. This green mineral is the altered product of a mixture of siderite and chert, in the form of granules and surrounded by carbonate of iron, from which the carbonic acid has been expelled, the ferrous oxide saturating and coloring both. The mineral is quite soft and is attacked by the ferric oxide surrounding it. The pure quartz which is sometimes found remaining in these cores has not the same cherty appearance. It has a granular, substranslucent aspect, and is also in the course of being changed into hematite.

Dr. Leith, of the United States Geological Survey, is perhaps nearer to the truth regarding the derivation of the iron ore deposits, when he advances the theory that the above mentioned green mineral, which he names "Greenalite," is the one which has furnished the iron. Unfortunately, when I recently had the pleasure of meeting Dr. Leith, the time at our disposal for conversation was only too brief, so that I am not quite fully informed as to how he considers the process to have taken place. I was also unable to procure his monograph on the Mesaba, which otherwise might have given me the desired information. Only this much I gather, that he seems to consider this "Greenalite" an ideogenetic mineral, and that from its appearance dates the commencement of the iron formation.

If we take into consideration the fact that the Mesaba iron-bearing rocks and iron deposits are very much truncated, it is readily understood how any observer could easily be misled in regard to this "greenalite" being an original mineral, for the upper, undisturbed and unaltered part of the chert is eroded and swept away there. Here this is not the case, and we are therefore in the fortunate situation of being able to see at many places the whole Animikie rock series still intact, as it was laid down. And from study of this we learn, as I have repeatedly stated above, that the original mineral is a chert and siderite granule, and that the "greenalite" is merely an alteration product of the former. Of course, if we take exception to this, that is to say, if we give no consideration to its original condition and begin to date the origin of the iron from the appearance of this mineral, then perhaps we might be in a measure justified in giving this green mineral a new name. In that case naturally we have to shut our eyes to the fact that this green mineral represents a certain phase already accomplished towards the forming of the iron. There is, however, another side to this question of the origin of the iron, namely that it did not owe its existence exclusively to the "Greenalite," but also to its original mineral ferruginous chert, yes, even to the jasperized chert, as we may see in some localities on this side, where large areas of this material are changed into hematite These different processes can be observed at many places. It is, therefore, problematic whether we are justified in assigning to the green mineral granules an importance which they do not quite deserve.

Neither the one nor the other of the above hypotheses fits correctly the origin of the iron deposits; my opinion of their origin, expressed in a few words is as follows:

"Water with free oxygen percolates along the slopes or other places in the ferruginous chert rock, descends through the capillaries of the chert, oxidizes the carbonate of iron, forming ferric oxide, and *the ferric oxide absorbs the silica.*"

I have no doubt that many after reading this will cross themselves in holy horror at such an heretical assertion, but I cannot help this, and as long as they are unable to prove me wrong, I won't go to "Canossa."

Our ever advancing scientific researches reveal to us almost every day something new, shed a new or clearer light on old doctrines and theories, and prove to us that many things which for years and centuries were regarded as practically gospel truths, are after all but erroneous opinions. For instance, they now tell us that these dear, solid, indivisible pets of ours, the elements, are no elements at all; that they are derived from one common source, radiating forth from what and whence they came. They further tell us that these elements—metals—are only weak beings, and not a hairsbreadth better constituted than we poor mortals, that they can become sick, yes, even could be poisoned.

Perhaps it might be of interest to relate here an experience in regard to this which I had several years ago with chemically pure tinfoil. One day, when I was going to make some chloride of tin, I observed that the upper portion of the sheets of tin, which I had in a cigar-box, laid out with paper, was perforated by a number of almost geometrically round holes, the rim of which looked dentated or jagged. My first impression was that I had spilled some hydrochloric acid on the sheets, and at the time I paid no further attention. Some time afterwards, coming across the box again, I saw the whole surface of the upper sheets full of holes, and eaten down through nearly one-half of the few hundred sheets of foil which were in the box. I took out the unaffected foils and wrapped them in a paper. A short while later I examined these, but could not detect the least affection. I now transferred two of the healthy sheets and placed them with the diseased, to see whether the latter would infect the former or not. In a very short time they showed exactly the same symptoms as the other. I now left this box undisturbed for several months but on returning home after a lengthy absence and taking up some work in my laboratory, I remembered the tin foil, opened the box, and found remaining only a small quantity of a greyish white substance, mixed with a few small specks of metallic tin. This could not have been more than from 5 to 6 grams, from at least 10 to 15 grams of the original tin foil. I put the box back with the intention of examining the contents later. Being absent for several weeks thereafter, I had no opportunity of doing so, but on my return I concluded that I would try to solve the mystery. However, on looking for my box, it had disappeared, and after every nook and corner of my laboratory had been ransacked, I found out at last from my assistant that he had relieved me of this work and used the "empty" box for kindling. What was it that caused this disintegration and contagious disease, what the seeming diminution of volume and weight? Was it the tin pest in its grey modification? If so, and if we attribute the disease to excessive cold, why was not the rest similarly affected, although exposed to the same temperature? It became so only after being in contact with the other.

Now if one has to credit these things, and I see no reason for not doing so, with as good reason as in the case of what we formerly believed to be the truth, then the reader has also to accept what I have claimed above, *i. e.* that there are among the list of our so-called elements "elements of prey." Perhaps the name "element" would no longer be the correct term; according to this new theory, "Electrons or Ions of prey" would be better. Now whether these electrons have a selective preference, according to their respective tastes, I do not know, but of this much I am certain, that there are two which would come under this classification—ferric oxide and magnesia.

For years I have studied and tried to bring the old chemical,

" Replacement Theory " into harmony with what I saw in the field and the mines, and especially in regard to the formation of the iron ores around Lake Superior. I did not succeed, and again and again I was led to the conclusion that some other process must exist for the production of these iron ores. There was no other way, no other possibility than to consider an " Absorption Process " by which these ferruginous cherts were converted into iron ore. Now in our case here, let us consider :

(1.) There is no flowing water, that is water flowing with such force into these ferruginous chert deposits as to carry anything out ; it is simply a moistening action by capillary descension through permeable rock. Further it could carry nothing in because there is no residual material from which anything could be extracted. If it had carried iron in solution into this rock, the carbonic acid of the siderite would have precipitated the iron out of it, and the precipitate would, by filling the capillaries, have stopped the whole process right at the beginning.

(2.) Through the oxidation of this rock and ore, heat is evolved and the incoming water is evaporated as fast as it comes down, and, fulfilling its chemical action, leaves the rock with the carbonic acid, which might also be a militant factor in attacking the silicate acid and preparing the way for the attack of the ferric oxide. The evaporation of water was doubtless considerably greater in the lower depth of our rocks, on account of the greater heat existing therein, especially in that period of recurring eruptions.

(3.) Moisture with free oxygen attacking the carbonate of iron which is mostly mechanically mixed with the cherty silica, is changing the siderite into ferric oxide ; the silica particles softened through the action of the carbonated water are then absorbed by the ferric oxide with the help of a fresh supply of oxygen.

I shall with the assistance of the new atomic theory mentioned above, explain this phenomenon in more detail and from a more practical standpoint, and thereby we may arrive nearer to a posslible solution.

We can say with almost certainty " that all matter is electricity," and further that electricity exists in three forms, (1), Static Electricity, (2), Electricity in motion, and (3), Electricity in accelerated motion. Hence, (1). An unaltered fresh piece of our rock would be a body—let me say—a latent body of electricity.

(2.) When this body becomes animated from one cause or another, we would have the second form, a body of electricity in motion.

(3.) When this motion becomes accelerated through a second cause, then we have the third form.

How can we explain this motion? I shall endeavor to illustrate this in the case of our rock,—the siderite and chert.

I have applied the term motion only to forms (2) and (3), but I must not omit to mention that there is a motion which exists in form (1), although it is only a motion within itself. This motion is that of the electrons which constitute the atoms of that body, of which we are taught that they follow a revolving motion of immense rapidity among themselves. To use an illustration, I might say that it is similar to that of the planets in the solar system. This then is the motion of the first form, which is called a latent motion, because it is not exerting any influence on an outside body. But what constitutes the motion of the second form? Perhaps the first impulse to this motion was the interference with the latent condition of the siderite by an outside medium, by which the carbonate of iron was changed into ferrous and ferric oxide, or, to express it in another way, by which the carbon dioxide of the siderite was eliminated, and oxygen took its place, sometimes in such proportion that the whole of the remaining ferrous oxide was converted into ferric oxide. It is likely that the medium which caused this change was water with free oxygen. The direct sequel of this action of the water and oxygen was another phenomenon, namely the evolution of heat by the oxidation of the siderite and liberation of carbon dioxide. This heat, added to that already existing in those rock strata, evaporated the water, which delivered the free oxygen. The steam produced thereby commingled with the liberated carbon dioxide and both attacked the silica of the chert, softening the chert granules. Thereby, in both these minerals,—iron and silica—was produced an "animated" motion.

Next we come to form (3), "the accelerated motion," for the production of which we may account in the following way:

Owing to the almost constant volcanic activity in the pre-Cambrian period, by which many dykes of different rocks were intruded into the Animikie rock strata, fumaroles and solfataras were produced, whose gases and fumes mingled with the meteoric waters; these acidulated waters also percolated into the spaces spoken of above, and formed electrolytes for the iron oxide and silica, which, as we have seen, were already in their second form of motion, but then arrived into their third form, "the accelerated motion." Now, as to the possibility of this, let us consider the iron oxides as a positive element,—the anode,—and the silica as the nagative element,—the cathode,—and assign to the acidulated water the function of the electrolyte. Some of these FeO and Fe_2O_3 particles dissolved, formed the anions, which would rush over to the cations of the cathode, and either combined with them to form Dr. Leith's "Greenalite," or took their places altogether, absorbed, them and formed ferrous, and at last ferric oxide electrons. In our study of these phenomena we might further take into consideration that the earth's magnetic or electric currents, which in the earliest history of our globe must have been considerably stronger and more frequent than at present, played doubtless a conspicuous part, in these changes in rocks and minerals, and it is therefore highly probable that they did so in the case we are dealing with.

Whether such a process as that described has existed for the conversion of the ferruginous cherts into iron ore, must of course be only a matter of speculation; but after studying the whole conditions under which this rock occurs, and how the changes within it took place, one can reach no other conclusion than that there was not, nay, there never could have been a replacement process in play, dissolving and eliminating the silica from this rock, and making room for the deposition of ferric oxide in its place. I must therefore again express my belief that there have been and are still phenomena going on in our earth's crust which are clouded in darkness, but with a better understanding and development of the new atomic theory, it may be that we will arrive also at a better knowledge of the methods by which these changes in rocks and minerals and ore deposits take place. The above hypotheses are simply brought forward by me to give a possible explanation of what occurred in these rocks, and of the formation of these iron deposits, comparing them with processes which we have before us every day, and supporting them with phenomena which have of late produced so profound an impression on every observer.

Some of the readers may ask, whence these deductions? I reply, from my studies in the field, at the mine and in the laboratory.

(1.) We have in this country a number of places where, on precipices, very plain sections of rock and iron are exposed, and where the process of converting the chert into iron ore was suddenly interrupted by the heat of the trap lava which overflowed the rock. Here we can see in the clearest manner possible how the iron ore was formed. Through the heat of the trap lava, hematite or limonite was converted into magnetite and the process ceased. The iron rests, I might say alternately, between the laminae of chert, in varying thickness, but seldom over one foot,. between layers of chert equally thick. In no instances can there be seen hollow spaces in the chert, not even honeycombed pieces, which might be recognized as indicating a removal of silica. Iron and rock are merging imperceptibly into each other, as if they were originally laid down together. Above and below these iron layers, we see how the iron was eating its way into the chert; sometimes two or three layers will connect at one or the other side or end. Now this iron, which is usually of very high grade, (68% to even 70% not being rare), is not of great extent horizontally and can be seen resting in the chert, by which it is often surrounded on all sides. No channels are visible by which the surface water could have found its way in, except by capillary descension or through percolation along the interstices of the laminae. This latter is however rarely observed, because in that case the whole infiltration channel would show signs of oxidation. The cherts lie horizontal, hardly any dip being observable. If the replacement theory were correct, open spaces, small or large, should be seen; also an infiltration channel through which the iron had come down and been precipitated into these spaces from which the silica had been removed. The reason why the iron lies nearly alternately between the chert may be the unequal oxidability of the rock. For, as I have remarked above, the iron carbonate in the chert varies in amount, which may be attributed, besides to the causes before mentioned, to the difference in the specific gravity of the two minerals.

(2.) In examining the hard ores in the workings of the Vermillion mines, we frequently notice how the pure iron is merging into the chert; even in the pure ore layers we find specimens which show no external difference, either in structure or color, from the chert, until, on breaking them open we find the pure iron. The gradation from the good to the poor iron is often so imperceptible that it needs a trained eye to detect it. If the iron had been carried in there, we should see principally good, pure iron, and not iron in all stages of purity, or—to express it differently—cherts in all stages of conversion. This can be observed on all ranges.

(3.) This process of the conversion of the cherts may be easily observed in operation upon a number of outcrops which were for long periods under water, and now through the receding of Lake Superior are exposed on the surface. Oxidation is progressing constantly by exposure as well as under cover of humus. Where the deposit is covered by humus and sod, the process goes on uninterruptedly, and it consequently shows a considerably greater advance because it is always kept moist and nothing is carried in except water and oxygen. Here we have another instance of iron being formed without being brought in from a belt of weathering.

(4.) It is principally by examination and study of drill cores from a large number of different places that we are enabled to observe and learn the various phases of this conversion or absorption process, but I do not remember having seen one from which we could draw the conclusion of the probability, or even the possibility of a replacement process. We see perhaps here and there at the surface of the chert rock specimens which have a honeycombed or amygdaloidal structure, but in this case it is readily seen that the oxidation products were washed out by the rain water.

(5.) In proving the existence of an absorption process, we do not need to confine ourselves to a single locality. I have seen cases of whole white clay beds, resting in spaces of an impermeable granite whence no means of escape for the silica or alumina existed, where ferric oxide formed all shades of yellow and brown ochre, even to a hard limonite. The same occurrence I noticed in the case of a white marl. Observe what Pliny says about the "Eagle Stone." (Aetites, Plinius, 36, 39.) Among other things he writes, "In the interior, (literally abdomen), they have a hard stone or soft clay which rattles when shaken." I have seen them almost solid, in which the interior, formerly silica, clay or lime, was completely changed into iron. I have also seen others which were solid, and had gathered about the periphery one layer after another of clay or other material, forming thereby concentric layers which consisted of nothing beyond the aforesaid materials, the outer of these layers being in all stages of the metamorphosis into iron, as could be easily observed when they were dug out of their resting places. Where did the replacement products go to, there being hardly any seepage of water to the outside? With the well known "bean ore" the process is the same. Possibly these phenomena are accompanied by some other reactions by which the whole process is assisted or accelerated, for instance, through carbonated or acidulated water, as I suggested above.

(6.) I mentioned above that magnesia acted in the same manner as ferric oxide. As an example I would give the peridotites of Maryland and Carolina, forming intrusions in a gneiss or granite. The final product is a beautiful white talc, no signs being visible of a replacement or dissolution of other minerals, with the exception of nickel, in the form of a genthite in the seams of the serpentine. This mineral, however, also disappears as the process advances farther.

Most interesting is it to follow this process in some of the Maryland rocks. At one place we have the unaltered peridotite, a little farther on we see the same rock changing into serpentine, still farther we notice a fine dark green serpentine, next we observe amygdules eaten into it by the oxidation of the ferrous oxide into ferric oxide ; this process must have been interrupted, the holes washed out and prehnite and sodalite infiltered into them. Next in order we see this rock changing into talc, the ferrous oxide disappears, it turns white, but the shape, form and volume of the rock remains, with amygdules and their contents intact, only these also changed into talc. Now I ask where did all the other minerals go to? Were they exchanged, molecule for molecule, for a silicate of magnesia? Whence then came all this magnesia? Not from the olivine alone. There are no signs of an influx of water containing magnesia any more than is the case with any other basic rocks changing into serpentine.

We could multiply the cases wherewith to prove that certain elements have the power of absorbing others, that is, their bases in ions or elections are stronger and absorb the weaker, and it may be that this theory will harmonize with the new theory of the origin, animation and existence of the elements, and it may be further that we will discover that most of the so-called "metasomatic" changes in rocks and minerals are nothing other than "absorption processes," such as that to which I ascribe the origin of the iron ore deposits around Lake Superior.

The Modern Blast Furnace Laboratory and its Work.

By W. DIXON CRAIG, B.A., Midland, Ont.

The history of the last half century has been largely the history of industrial chemistry and in no branch of manufacture has chemistry played a more important role than in the manufacture of iron and steel. I should preface this paper by stating that it aims at being popular rather than technical in the hope of interesting a larger audience.

Following the logical order, we shall first then consider the work of the laboratory, and later, the laboratory itself.

The work of the blast furnace laboratory falls naturally into three sections: analysis of raw materials, analysis of product, and analysis conducted for furnace control; the analysis of both the raw material and the product are also, as will be seen below, absolutely necessary for control of the furnace.

Although the knowledge of the chemical reactions which take place inside the furnace has not been reduced to so exact a science as the knowledge of some other processes, nevertheless it is quite allowable to say that we know enough of these reactions to afford definite guidance in the burdening of a furnace. The problem of burdening a furnace may be stated thus—Given ore, coke and limestone—in what proportions shall they be put into the furnace in order, 1st, to make iron, and 2nd, to make iron suitable for a certain purpose? By purely empirical juggling with these various constituents good suitable iron has been made. But to get constant results, we must know the constituents of the raw materials If iron ore were pure iron oxide, limestone pure carbonate of lime, and coke pure carbon, one analysis would suffice forever. But iron ores are as varied as human nature and limestones are strikingly different, not only in different localities but in different beds of the same quarry, while cokes are also of many descriptions.

Before the furnace can be properly burdened then, it is necessary to have a full analysis of the ore, limestone and coke used.

The constituents generally determined in an iron ore are metallic iron, silica, phosphorus, manganese, alumina, lime, magnesia, sulphur and moisture. Special ores often require further special determinations. Each ore in use is analyzed once a week for the more variable constituents, and at certain intervals completely.

Similarly, the limestone is run every week for iron, silica, alumina, lime, magnesia, and occasionally, for sulphur and phosphorus.

Coke is tested for sulphur every day, and at stated intervals analyzed for moisture, volatile, fixed carbon, ash, iron, silica, alumina, lime and magnesia.

I need scarcely point out that the samples of these various materials must be taken very carefully or the analysis will not represent the stock accurately and will consequently be worthless.

We see then, that before any material is allowed to enter the furnace, it is subjected to a chemical analysis. Of course, some ores are more desirable than others, generally because they are richer in iron. Other ores again are useless on account of high percentages of sulphur. Still others are most desirable for making Bessemer iron on account of their low phosphorus content. It has thus come about that ores are bought and sold on chemical analysis. The furnace laboratory is, then, called upon to sample and test the ore received, to see if it comes up to specifications. Every cargo or carload of ore received is sampled and tested completely. The selection of a sample from a large cargo of ore thus becomes a very important matter. It may not be out of place here to state that the largest cargo of ore received at a Canadian port arrived in Midland, on Nov. 22nd, 1902, per the Agawa, of the Algoma Central Steamship Line.

In the same manner and for the same reasons, the limestone and coke received must be tested by the laboratory to make sure that they come up to the requirements.

The analysis of the product of the furnace—pig iron—is just as important as the analysis of the raw material. Iron is still very generally graded by fracture, but chemical analysis is coming to be regarded more and more every day as the most reliable test of the quality of pig iron.

The largest consumers of pig iron buy on chemical specifications. In making Bessemer steel, an analysis of the pig iron used is absolutely necessary if a uniform steel is to be produced. However, it is not my intention to make *ex cathedra* statements as to the relatives merits of grading by analysis and grading by fracture. The question is still a more or less controverted one. I would, however, point out the folly of regarding chemical and physical tests as opposed to each other. Chemistry and physics are mere arbitrary terms used by us to define our ignorance. No one science is separate and distinct. Our object is to know all that is to be known about a certain iron. The great advantage that the knowledge gained by chemical analysis has over the knowledge gained by inspection of the fracture is that the former is definite and unprejudiced while the latter is empirical and depends largely upon the grader's opinions and judgment.

When we come to consider the analysis of the iron as a factor in the control of the furnace, we see how important it is. Every cast is analysed with the utmost speed in order that the man in charge of the furnace may know what kind of iron has been made, and thus what he must do to get the same iron next cast, or to improve the grade of the next cast. Every cast is analysed for silicon and sulphur, and phosphorus and manganese are determined in a certain number of casts depending on what kind of iron is being made.

The result of the analysis is in the hands of the furnace superintendent long before the iron is cooled. Half an hour always suffices for analysis. Many casts are run in far less time than this. If the furnace superintendent had to depend upon the fracture of the iron for his knowledge, he would have to wait considerably longer and thus make his changes so much later.

Every pound of iron produced is thus analysed for the purpose of affording guidance in the running of the furnace and supplying the market intelligently.

Already it is the custom with all large consumers of pig iron in the United States to buy strictly on chemical analysis. This practice is spreading and it is only a matter of time before most of our Canadian consumers will follow suit. The advantages of this are apparent at a glance. The foundryman or steel maker, knowing the character of his stock, can order iron of the most suitable analysis. He can test closely the iron he receives, thus making sure he is getting what he is paying for. On the other hand, the manufacturer of iron is relieved of all responsibility after supplying the desired iron, and runs no risk of having his iron blamed for bad results which are due to another brand.

While pig iron is the product proper of the blast furnace, it also produces two other materials—slag and gas.

A knowledge of the chemical nature of the slag is of great assistance to the furnace superintendent. While this can be estimated roughly by its appearance, it is usual to have a sample taken from every flush, and an average sample made up from these to represent the twenty-four hours—thus checking the work of the furnace. To illustrate the value of this—A certain burden is put on the furnace, calculated from the latest analyses at hand; by calculation, the slag should have a silica content of 32 per cent. After twenty-four hours running, the slag is analysed and found to run thirty-six per cent. in silica. It is needless to remark here that this will have a considerable effect on the iron produced. Knowing the analysis of the slag, it is a simple matter to calculate just how much more limestone should be added to the burden to bring the silica back to thirty-two per cent. In this way close watch may be kept on the furnace. The slag is analysed every twenty-four hours for silica, alumina and lime. The gas is more rarely tested. A knowledge of its composition, however, often affords a valuable aid to the control of the furnace.

I now give some detailed notes on some of the methods of chemical analysis used in the Midland Laboratory.

PIG IRON.

Silicon.—Textor's Chromic Acid Modification of Drown's Method.

To one gram of drillings in a number 4 casserole add 15 to 20 c.c. of water; then 25 c.c. Silicon Mixture. (1 part Sulphuric Acid, 1.84 specific gravity, 2 parts Nitric Acid, specific gravity 1.20), heat over a small Bunsen flame till dissolved or violent action ceases and evaporate rapidly over full Bunsen flame without use of gauze or asbestos board. When the solution has evaporated sufficiently, the iron sulphate becomes insoluble and is thrown up against the cover glass. Remove from the lamp and while hot add 15 c.c. of a water solution of chromic acid, (120 grams to a litre of water), boil again as before, until the chromic acid crystallizes out. Remove from lamp, add hot water, slowly at first, boil a few minutes or till dissolved and clear ; filter, Wash the chromic acid out of the filter with hot water, then wash with warm dilute hydrochloric, and lastly three or four times with hot water. Ignite and weigh. *Precaution.* The evaporation with chromic acid must not be carried too far, otherwise insoluble salts are formed. On the other hand, if the heat is not continued long enough, the graphite will not all be oxidized. The small amount of graphite occasionally remaining is very quickly burned off in the ignition.

I have given the above method in detail as it is not very well known and is an extremely rapid method for pig iron. It is very accurate and simple. Determinations in our laboratory are run regularly in 20 to 30 minutes.

Sulphur.—The evolution method is employed. The iron is treated with dilute hydrochloric acid. The sulphur is evolved as hydrogen sulphide, which is collected in an ammoniacal solution of cadmium chloride. The precipitate of cadmium sulphide is finally dissolved and the solution titrated with standard iodine solution, standardized by a standard iron. Some improvements on and modifications of this method are now being tested in the laboratory.

Phosphorus.—Emmerton's method is used as given by Blair. (1) The standard solution employed is standardized by a standard iron.

Manganese.—A modification of Volhard's method (2) is in use at present. A new method is being thoroughly tested, and if accurate, will be adopted. (3)

Graphite.—Method as given by Blair. (4)

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(1) "Chemical Analysis of Iron."—Blair.

(2) "Chemical Analysis of Iron."—Blair.

(3) "Journal Amer. Chem. Soc. XXIV, 1204."

(4) "Chemical Analysis of Iron."—Blair.

Combined Carbon.—Eggertz Color method. (1)

In four of the above methods a standard iron is necessary. The standardized drillings of the American Foundrymen's Association are used, and one cannot speak in too high praise of the enterprise and thoughtfulness of this association in preparing this laboratory necessity in such an admirable manner.

ORES.

Metallic Iron.—Solution in hydrochloric acid, reduction with stannous chloride and titration with potassium bichromate. (2)

Phosphorus.—The ore is brought into a nitric acid solution, the insoluble residue being fused, if necessary, and then determined as in pig iron, except when titanium is present—*vide infra.*

Manganese.—The ore is brought into nitric acid solution, the insoluble residue being fused, if necessary, and then determined as in pig iron.

Sulphur.—The *Aqua Regia* method is used. I would note here the importance of two points in this method—a double evaporation to dryness before the insoluble residue is filtered off, and secondly, after precipitation by barium chloride, the evaporation of the solution to very small bulk in order to drive off the acid and render the barium sulphate completely insoluble. These two points are often overlooked.

Silica.—The ordinary separation by evaporation is used. The ore is decomposed in hydrochloric acid, filtered, the residue fused and the fusion dissolved in the filtrate. This solution is evaporated to bone dryness, taken up in hot water and hydrochloric acid, filtered, and the filtrate evaporated to dryness, dissolved, and again filtered, as recommended by Hillebrand. (3) The two residues are ignited and weighed as Silica.

Alumina.—The alumina, lime and magnesia are in the filtrate from the silica. The alumina may be separated by the basic acetate or ammonia separation. The precipitate of ferric oxide and alumina is dissolved in dilute hydrochloric acid and the alumina precipitated from this solution as aluminum phosphate by Camp's Method. (1)

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(1) "Chemical Analysis of Iron."—Blair.

(2) "Chemical Analysis of Iron."—Blair.

(3) "Journal American Chemical Society. XXIV. 562."

Lime and Magnesia.—Are determined by ordinary methods. (2)

Titanium —This determination is generally required in ores in which phosphorus occurs. Gooch's method is used. (3) Many of the methods recommended for the determination of titanium and phosphorus are unreliable because they fail to make a complete separation.

Limestones.—The ordinary methods (4) are used. The same precaution is adopted in determining the silica as in ores. Lime is determined by titration with potassium permanganate.

Cake.—The ordinary methods are used. Sulphur is determined by the fusion method. Eschka's method has been used, but in our experience, cannot be fully relied upon.

Slag.—Ordinary methods are used, very similar to those used for limestone. I have given above a short *resume* of the analytical methods employed for iron work in the Midland Laboratory. It should be understood that new methods are being looked for always and tested as to their desirability. Details of these methods can, of course, be found in the references.

It may be of interest to note that a committee of the American Foundrymen's Association is at present at work on the selection of standard methods for the analysis of pig iron and that this laboratory is participating in this work.

I should now like to say a few words on the relation between the Canadian Mining Institute and the work of the Blast Furnace Laboratory

Granted that the iron industry of Canada has a future of importance, it behooves this Institute to keep in close touch with it, and hence with the laboratory and its work. I have referred above to the work of the American Foundrymen's Association. This body has prepared a set of four standardized drillings which have proven of inestimable value to iron chemists and the iron industry at large They have also put forward a standard method of sampling pig iron which is now on trial. As stated above, a committee of the association is now at work on the selection of standard methods for the analysis of pig iron.

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(1) "Methods of Iron Analysis."—Phillips.
(2) "Chemical Analysis of Iron."—Blair.
(3) "Chemical Analysis of Iron."—Blair.
(4) "Chemical Analysis of Iron."—Blair.

The American Chemical Society also, has published valuable standard methods for the analysis of coal and coke.

Now, while Canadian chemists profit by this work, I look forward to the time when these matters may be controlled by a Canadian Society.

While it would be too much to expect the Institute to take up this work at the present time, there is a need which it might meet.

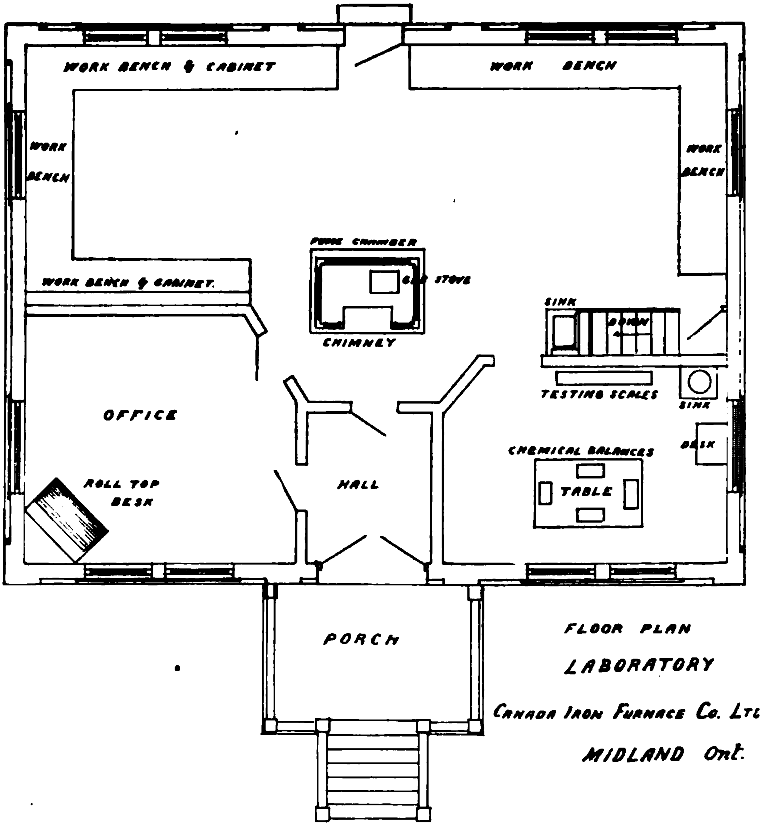
A standard iron ore would be of great value in a furnace laboratory and in many other directions. Prepared by the Canadian Mining Institute, it would be a reliable standard for use all over Canada. At the same time, it would be a start in the right direction. The Canadian Government might reasonably be expected to assist in this, as the matter concerns it in the analysis of iron ores required in connection with the bounty on pig iron.

Another work which would be of value is the selection of a standard method of sampling ore cargoes and car shipments. This would result in the avoidance of disputes between buyer and seller

One further suggestion I would throw out before, leaving this subject—the formation of a chemical section of the Institute. While probably many Canadian chemists are, like myself, members of the American Chemical Society or the Society of Chemical Industry, I believe that a section devoted to mining and metallurgical chemistry would be welcomed by those chemists who are already members of the Institute, and might result in the acquisition of new members. This section might be allowed to hold a one day's or a half day's session at the meetings of the Institute in which technical papers could be read. I believe this would assist in making the Institute the premier Canadian Society.

I do not elaborate further on these points as I hope they will call forth valuable discussion, giving the Institute more weighty opinions than my own.

Having taken up the work of the laboratory, I now turn to the laboratory itself. As far as this subject goes, I cannot do better than give a description of the Canada Iron Furnace Company's Laboratory at Midland.



The Laboratory is situated on the hill, back of the furnace plant, over-looking Midland Bay. Being some distance from the furnace, it is as free from dust and vibration as possible. Every chemist will understand what a valuable consideration this is. The building faces south and is 30 x 40 feet and from 30 to 40 feet in height. It is constructed of sold brick, with granite foundations and trimmings. The most noticeable point from an exterior view is the large amount of window space. On the south aspect, or front of the building are two large windows, each subdivided, and a glass panelled entrance. The other three sides of the building are provided with two windows each. There are three entrances to the building. In the front is a spacious porch and double doors leading into the hall or vestibule. On the north or rear wall is another half glass door, for the convenience of the laboratory staff. At the east side of the building is the basement entrance for the reception of fuel and laboratory supplies. The main entrance and all the windows are provided with awnings for the summer season.

The draught stack appears in the centre of the roof, which is constructed of fire proof cement. The general design of the building is similar to that of the other permanent buildings on the plant.

The main entrance leads into the hall, from which doors open into the office and laboratory proper. A fire extinguisher is kept in the hall in case of emergency.

The door leading into the office is provided with a glass panel bearing the initials of the company—C. I. F. The laboratory door is private and is the only door on the main floor entirely constructed of wood. An oak wainscoting runs around the wall; this is continued in all the other rooms, the laboratory included.

The office, which is 13½ by 15 feet is intended for the use of the chief chemist, and for the housing of the mineral collection which is maintained in connection with the Exploration Department. In this collection are specimens of ores, chiefly those of iron, from all parts of Canada, more especially of Ontario. Specimens are being added to this constantly. The nucleus of a technical library is also kept here. It is the intention to gather about this an extensive collection of geological and chemical works. The windows of the room look on the south and west and command a complete view of the plant. A private telephone connects with the other departments. A glass panelled door opens from the office into the laboratory. The three front rooms, office, hall and balance room, are separated from the main part of the building by a ceiling and walls 16½ feet high. As the roof of the building constitutes the ceiling of the laboratory, there is a considerable amount of space above these rooms. The walls of the laboratory are 20 feet height; above this the roof slopes from all sides to the apex, which is 30 feet from the floor. The roof is supported by two trusses and suitably finished with a wood ceiling. There are two ventilators placed in the roof for carrying off foul air and any stray fumes. The shape of the roof, admirably adapted for the collection of fumes, and its extreme height, are very important factors in keeping the laboratory atmosphere pure. The room is 14½ by 38½ feet.

In the center of the building, and consequently on the south side of the laboratory, the draught stack rises. The fume cupboard, or hood, is built around three sides of this. It is 9¼ feet long by 4½ feet wide. The total height is 13 feet and the walls are 9 feet high.

It is provided with a two inch blast pipe from the furnace blowing engines, running up the inside and into the opening into the draught stack. This provides a perfect forced draught. All operations in which noxious fumes are produced are conducted under this hood and the fumes instantly removed by the strong draft. The working surface of the hood is a heavy slate slab entirely unaffected by any acids which may be spilled on it. The hood is made of solid, polished oak and forms a very handsome piece of laboratory furniture. Below the slate slab is a large locker. The hood is fitted with twelve gas cocks and provided with a large hot plate 19½x22½ inches, and one large ideal gas burner providing a second smaller hot plate. Inside the hood are two small shelves for the reagents used in running the casts for silicon. The sashes of the hood may be raised or lowered at pleasure. At either end, just outside the window sashes, is an electric lamp.

The work tables run along the walls of the room, just below the windows. These are 30 inches wide and 3 feet high; there are 54 running feet of working space. There are two windows on the north side and one at each end of the room. Thus every table but one has a window immediately over it. There are five tables, one at each end, two on the north side and one on the south side, against the office. Over the latter is a set of shelves for glassware and chemicals. The table tops are of wood, painted black and waxed with paraffin for protection against acids. This description of tables has been found very satisfactory.

Along the inner side run three sets of pipes with cocks at intervals.

One of these pipes is for gas. The second comes from the blast pipe in the basement which leads from the blowing engines; this provides blast for the blast lamps. The third pipe comes from a very powerful filter pump in the basement, producing suction for rapid filtration. Thus, by simply opening a cock, gas, blast or suction can be obtained at different places on each table. These pipes are boxed in, forming a small shelf at the back of each table for apparatus and work under way. Above this shelf is a second one of plate glass, running along above each table, for reagent bottles. A plate glass shelf can always be kept clean, which is impossible in a wooden shelf on which reagent bottles are kept.

Above each table hang two electric lamps for night work. Under each window, below the table, is a large hot water radiator. The tables are provided fully with drawers and lockers of oak.

At the east end, on the south stde of the room, is the door leading to the basement stairs, which are closed in by an oak closet. On the top of this closet is kept a carboy of distilled water. At one end of this closet is the sink and draining shelves for glassware.

The situation of this work room on the north side of the building obviates much trouble from direct sunlight, while its shape, long and narrow, and the large windows, ensures perfect light in all parts of the room. The loftiness of the ceiling keeps the atmosphere as clear as is possible in a busy laboratory.

South of the laboratory, at the east end of the building, is the balance room, which is entered by a swing door with glass panels. It may seem superfluous to say that a swing door for the balance room is a wonderful convenience, but it is surprising to know that many laboratories lack this feature. The room is is 15½ feet by 8¾ feet and has windows on the two sides of it. In the middle of the room is a concrete pier, separate from the floor and resting on its own foundation in the basement. This prevents any jarring of the balances. This pier is cased in panelled oak and on the top is a polished oak slab

3½ feet by 5¾ feet for the balances. There are two Becker and one English balance, and a pair of counter scales on this table. Each balance is provided with an electric lamp. The position of the table, in the center of the room, is to be recommended on account of the advantages of having the light come from behind while weighing. The windows are provided with sash curtains for keeping direct sunlight off the balances, while at the same time not shutting off the light entirely from the room.

On the north side of the room stands a Buffalo Testing Machine for making physical tests on the pig iron. The room is also provided with a wash stand, desk and hot water radiator.

The whole building is floored with maple, and finished throughout with oak.

Gas is obtained from a 50 light gas machine of the Detroit Heating and Lighting Co. This has given perfect satisfaction and is exactly the equivalent of city gas in point of convenience.

The basement is the full length and width of the building. In one corner is a store room for supplies and chemicals, in which the gas machine is kept. A Preston boiler for hot water heating is placed beside the base of the stack. In another corner of the room is the concrete pier for the balance table.

There are five sets of pipes in the basement—for hot water heating, gas, water, blast and suction. There are three windows and a door, referred to above. The floor is of concrete and cement.

I should explain that the equipment for handling samples is in the machine shop. A steam power sample crusher, grinding mortars, steam bath, mixing floor, etc., provide facilities for handling very large samples of over a ton, as well as smaller ones.

Altogether, it may be said that this laboratory is one of the finest in America. Its situation, design and finish would be hard to improve upon. It was designed by Mr. John J. Drummond, General Superintendent of the Company, built by Foreman Mr. George Beatty, now Superintendent of the Londonderry Iron & Mining Co., Londonderry, N. S., the writer being responsible for many of the details. I may best conclude this sketch by saying that the character of this laboratory is one of the hopeful features regarding the future of industrial chemistry in Canada.

Notes on Machinery Constituting a Mining Plant.

By Alfred C. Garde, M.E., Sandon, B.C.

The following notes may be found useful to mine investors and engineers in charge of mining properties, and, although written with a particular view to conditions in British Columbia, pertain to mining elsewhere as well.

From the very time that a mineral claim passes out of the prospector's ownership the question "how to work the property at the least expense and with the best results" presents itself to the investor, and that this has been an important as well as a difficult question nobody will doubt when referring to the numerous idle plants of more or less value found in nearly all mining camps.

Any mining failure cannot but reflect on mining in general and should therefore be guarded with all possible care by the professional engineers.

To make a paying investment and a mine out of a prospect without employing other power than hand labour is hardly possible nor excusable now-a-days, except perhaps where the formation is unusually soft and the ores of very high grade, or possibly where the property is remote from any convenient point of transportation. In certain sections of the Slocan and Lardo districts conditions of this nature exist, but, being rather exceptional, do not exactly come under the class of mines referred to here.

Hand labour should therefore only be employed to prove the property to a reasonable depth, perhaps one hundred feet or so, or sufficient to warrant the investment in a medium sized hoisting plant: but here I have frequently observed that instead of getting a medium sized hoist, say a 10 x 12, that would develop the property for a couple of years, a large plant, and sometimes even direct motion hoists with corresponding equipments are put in. Anyone that is interested and makes inquiries why a smaller plant would not have answered the purpose, receives invariably the same answer, viz.: Expectations of having a great mine some day, which would make it impossible to get along with anything smaller. If the mine turns out to be wonderful, good and well, but the chances for becoming a great mine are nearly always against the prospect. The number of claims recorded every year compared with the number of paying mines shows this only too well; but even supposing that the small hoisting plant, within a couple of years, should have to be replaced with a larger one, there is hardly a stock-holder to be found in any country that would not be pleased to learn that the mine was producing ore so rapidly that the original prospecting plant was now unable to cope with the increased output. The above does not pertain to hoisting plants alone, but to all matters pretaining to mining and milling investments as well, and it is hardly necessary to add that if this first principle of economy in mining ventures had been followed out more generally during the past history of mining in British Columbia, considerable of the investors money and disappointment would have been saved.

Hoists.—In regard to hoisting machinery I find that it is quite common to see ordinary cast-iron gears and pinions used. As a matter of fact a hoist should not be permitted to handle men anywhere without having the most perfect kind of gearing. I would recommend the use of a cast-steel gear with well cut teeth running together with a rawhide pinion. I have used this design successfully even on large double cylinder hoists, where the hoisting speed at times would exceed 1000 feet per minute, and where a speed of 600 feet per minute with the ordinary cast-iron gears would be considered unsafe and excessive. The rawhide pinion also does away with 50 per cent. of the objectionable noise peculiar to geared hoists, and reduces friction as well as wear of teeth.

Where two drums have to be used the main shaft should be in one piece and supported by three pillow-blocks. One substantial gear with rawhide pinion, placed as close to the centre journal as possible, will be found to give better satisfaction than two smaller gears on either side. Drums should be loose on the shaft and provided with removable composition metal bushings. Each drum should be operated by an independent friction clutch, keyed to the shaft close to the main gear, so that the drums can be run in balance or independent of each other as required. The engine should be fitted with reversible link motions of forged steel.

For brake device I prefer the post brake to which a very neat safety contrivance for over-speed can be attached. It consists of a small speed governor geared from the main shaft. Whenever the speed exceeds the safety limit—say 1000 feet per minute—the automatic governor will cause a throttle valve to open, thus permitting steam, or preferably, compressed air, into two small air cylinders having their piston rods directly connected with the post brakes in such a manner that the compressed air forces the piston down, setting the brakes at the same time. One mutual governor will do for both sides but each post brake must have its own independent air cylinder.

To take care of the surplus hoisting rope and to save the dead coils from being worn by that portion of the rope which is in constant use a false reel can be placed inside of each drum, and so arranged that the extra rope can be conveniently let out through a slotted hole in the rim of the drums whenever required. This avoids rope splicing.

Unless the mine is producing 500 tons per 24 hours from a depth of 1500 feet or more I prefer a self-contained double cylinder 14 x 18 geared hoist of the above description even to a first-motion hoist. The amount of material that a hoist of this character is able to handle is quite astonishing, especially where two skips, each of the two tons capacity are used.

Skips versus Cages.—For vertical shafts where the vein is perpendicular, or nearly so, it is only fair to admit that the well known mining cage has done good work, but wherever it is possible to use a skip or skip-car I always prefer it to the cage. Within the last few years the skip system has gained much favour and has been introduced pretty well throughout all the large mines in Butte, Montana, as well as South Africa, both for vertical and incline shafts. It stands to reason that where a large amount of material has to be handled from several levels and from a considerable depth, a single-deck cage with room for 1 ton car only is quite insufficient, and two, three, or even four, deck cages will have to be employed to do the work; in such cases the combined dead weight of cages and cars becomes both enormous and impracticable. I remember two well know mines in Butte where four-deck cages were used until a five ton vertical skip was introduced. Each deck was carrying a one ton ore car, and the combined weight of four cages and four empty ore cars aggregated 9600 pounds, or 2400 pounds of steel per ton of material hoisted, while a five ton vertical skip that was put in later on only weighed 5000 pounds, being equal to 1000 pounds of steel to one ton of material hoisted. Where good fuel is expensive, and several thousand tons of material are hoisted every day, as in the above case, the amount saved in coal represents a very handsome yearly dividend. The same rule also applies to a smaller hoisting plant. The average weight of a standard mining cage is about 1200 pounds and a 16 cu. ft. standard ore car weighs about 800 pounds, making a total of 2000 pounds, while a one ton skip, or a skip car with safety clutches, will not exceed 1500 pounds If 200 trips are made during 24 hours the extra dead weight would amount to 50 tons or 25 p.c. of the hoisting capacity.

To make the skip system a success it is necessary to have bins or ore pockets cut out at each station in the mine so as to receive the ore or waste made during one shift. When the car-man has emptied his car into the ore pocket he returns to the chute to refill it. Any time during the shifts the pockets are emptied and it will then require a man at the bin gate to fill the skip and prevent spilling of material down into the shaft. This last feature was solved in vertical shaft propositions when the pneumatic ore-bin gate was introduced in Butte, as it enables the operator to shut off the ore stream within a second, or in other words when the skip is loaded. In addition to the pockets at each level a storage bin will be required at the top landing. Depending upon the arrangement several combinations for handling both ore and waste on top can be made, depending upon the ingenuity of the engineer in charge. It will readily be seen from the above that by the skip system, economy in labour is possible, and the proverbial "waiting for the cage" is done away with. The skip is equally as convenient for handling men and material up and down in the mine and is safer than a cage.

It is generally advisable to have a large bin capacity on top as it is often necessary to store different classes of ore. Ideal conditions are those where the ore can be loaded directly into railway cars. A crusher and screen placed above the bin will always be found convenient for breaking and sizeing the ores. Ore bins and gallows frame can usually be built together, and I think that in British Columbia wooden gallows frames are preferable to expensive steel ones. The danger from fire is equal in both cases, as wood cannot be avoided for the construction of floors and the cost is at least twice as much again as the best wooden frame.

Head sheaves should always be large, and lined with rubber or hemp to save the hoisting rope. Wrought iron spokes cast in with the hub and rim should be avoided as the spokes will soon get loose and commence rattling. Substantial shafts made of hammered steel and self oiling journals are recommended.

For hoisting rope a flexible plough steel, six strands 19 wire rope, is the best. For a skip of one ton capacity a ⅝ in. rope is sufficient, and for a two ton skip ⅞ in. It is very common to find too heavy rope used, which, unless the sheaves are proportionately large, will ruin the rope within a short time. The most convenient incline in a shaft using skips is 70 degrees. Rollers should be provided at intervals in the shaftway, thus preventing the rope from dragging on the foot wall.

For inside work over winzes and for sinking purposes, I like a friction hoist. It is not exactly the type of hoist that should be placed over an important outside working shaft, but will be found extremely convenient for prospecting with a bucket or small skip. Care should be taken that the hoist is not overloaded.

Where compressed air is used for hoisting purposes it will nearly always pay to re-heat the air just before entering the cylinders. The re-heater should be placed as close to the hoist or air drills as possible, and all pipes wrapped with heat and waterproof asbestos covering. It is not always convenient to use coal under ground. In some cases coke, if not too expensive, might be used.

British Columbia is extremely fortunate in possessing large areas of desirable steaming coal, a feature which, I think, is only surpassed by the abundant water power distributed over the greater portion of the province. No other section in North America can probably equal it in that respect. I think too little attention has been paid to the use of water power for mining purposes in B.C.

Notes on Roasting with McDougall Furnace.

By S. S. SORENSEN, Murray, Utah.

Having had occasion to give some time recently to the study of the working of a set of eight McDougall calcining furnaces at the Highland Boy Smelter, Utah, I have just put together a few notes which with the kind permission Mr. R. H. Channing, General Manager of the company, I now beg to submit to the Institute, in the hope that they may be of some interest or use to some of the members.

I am specially indebted to Mr. Channing for the valuable information and figures relating to the performance of these roasters and for his kindness is allowing me to carry out the few special tests and observations I have made in studying their working.

Though called "McDougall" these furnaces are of improved design got out by Mr. F. Klepetko, and embrace several points covered by patents issued to Messrs Klepetko and Evans. The Herreshoff furnaces, which are considerably advertized, are of the same general arrangement though differing in important features. And there are several other variations in details affecting this type of furnace for which U. S. patents have also been issued, as for instance those of Wright and of Meech.

There being only comparatively few plants as yet at which this style of calcining furnaces has been installed and only one of these, as far as the writer is aware, in Canada, it may not be out of place if I begin with a general description of the plant at the Highland Boy smelter. The accompanying drawings are perhaps the most lucid and time-saving description, to which I need only add a few words of explanation.

At the Highland Boy the furnaces are contained in a building 100 ft. x 64 ft., and are placed in two rows of four, the rows being 21 feet apart C. to C. Longitudinally they are set at 18 ft. C. to C.

The furnaces themselves are of the vertical cylindrical type 16 ft. dia x 18 ft. high and are divided horizontally into six chambers, or "floors," by means of flat brick arches having circular openings at the centre of each. Through the vertical axis of the cylinder there is a hollow built-up cast iron column, or shaft, to which are bolted two diametrically opposite hollow cast iron arms in each chamber. These arms are set at 90 degrees at each successive floor. Seven and eight removable cast iron rabbles or ploughs are mounted on opposite arms respectively. The central shaft extends through the bottom of the furnace and is carried by a footstep bearing, above which sits the bevel gear-wheel for driving it. At the top, the shaft also extends beyond the crowning arch and is supported in a journal-box attached to steel girders which span the furnace. On the shaft above this journal is the gear-wheel which drives the feed mechanism. And above this again the annular trough which receives the circulating water discharge from nozzles in the extension of the shaft.

One of the special features of this design of furnace is the water cooling in the central shaft and radial arms, and it is for this purpose that these are made hollow. The circulation is provided for thus: About 8 ft. of 6 inch pipe is fixed to the top of the cast iron shaft as a head or pressure pipe. This is suitably reduced down, and connected with the down conduit, or duct, inside the column, which has branches leading off independently to the end of each arm. Cold water is thus forced under the above head down to the bottom of the shaft and to the end of each arm whence it returns carrying off the superfluous heat from the castings and discharges by the nozzles before mentioned. This cooling secures the strength and endurance of the castings. It does not, however, apply to the rabbles themselves. They are not water cooled. Simplicity and cheapness and convenience in slipping on or off are the chief aims in their design. It is thought that the complications of water cooling the rabbles would outweigh the advantages to be gained thereby, whereas the rabbles as used, are very readily removed or replaced.

The shell of the furnace is made of light rivetted boiler-plate, lined with 9 inch brick work.

The cast iron sectional bottom, supported on steel I-beams resting on cast iron foundation pillars, are 14 ft. above the ground level to give room for the steel hoppers for the calcines which discharge through bottom doors into the 4-ton tram cars.

The ore is run in at the top of the building, some 50 ft. above the ground level, and dumped into feed pipes 4½ ft. dia. and about 10 ft. long, which are tapered off on two sides at the lower end to fit into the rectangular mouth of the feeders. The feeding is automatic, and the mechanism is a simple and efficient contrivance. Immediately below and 3 inches lower than the nearest part of the throat there is a horizontal shelf subtending the said opening. It is of the same length as the throat opening but wider. The edges thus extend beyond the angle of repose of the ore. A positive definite feed is obtained by two cross-bars or pistons mounted on horizontal rods which are given an adjustable reciprocating movement alternately pushing the ore over the farther edge of the said shelf and pulling it on its return stroke over the nearer edge. The length of this stroke determines the amount of feed and is regulated by altering the radius of the lever where it is attached to the connecting rod.

Now to trace the progress of the ore through the furnace: The position of the delivery of the ore from the feeder is near the outer circumference of the top or No. 1 floor. The rabbles on this floor are set at an angle which causes the ore to be moved towards the centre. The opening at the centre on this floor is large, affording an annular space between its inside edge and the centre column through which it falls continuously as it is pushed over by the innermost rabble. On the second floor the ploughs are set oppositely so as to move the ore from the centre to the circumference, where there are six drop-holes through which the ore drops to No. 3 floor, and so on alternately till it is discharged through two drop holes into the calcines hoppers above referred to.

Each furnace is driven through a friction clutch affording both independence and a measure of safety in case of obstruction.

In working these furnaces on Highland Boy ore, running about 35 per cent. sulphur, no fuel is used except for warming up when starting, though on the same ore in a straight-line type of furnace, in

which half the output is roasted, coal to the extent of 10 tons per diem is being used. This is due to the construction of the McDougalls:

(1) enabling the supply of air to be closely regulated;
(2) preventing the suction of unnecessary cold air into the furnace;
(3) causing ALL the air required to flow against the stream of the ore so as to be progressively heated by the radiation and combustion, first from the more inert nearly roasted calcines at the bottom, up to the floor of maximum oxidation activity, above which, though then poorer in oxygen, it is still chemically able to efficiently remove the more unstable atom of sulphur, and finally, physically to carry off the moisture in the raw ore.
(4) preventing loss by radiation, the ontside surface being small relatively to the cubic contents, all of which is efficiently used while the whole of the shell is lined by not less than 9 inch brick-work; and
(5) when once fairly started, obtaining from the heated brick-work in shell and arches an excellent thermal fly-wheel.

The average duty on crushed ore is about 35 to 40 tons per diem at which rates the sulphur is reduced from about 35 per cent. to 6 to 9 per cent. respectively. The time taken for the ore to pass through the furnace proper is 2½ to 3 hours with a consequent small lock-up of the ore. There are, in fact, only from 25 to 30 tons contained in each furnace at one time (including contents of feed and calcines hoppers, using a good average depth of ore-bed on the floors for the above stated grade of calcines.)

From the above description it will be seen that there are two elements in the thorough and rapid roasting of the ore, viz, (1) the constant gentle stirring by the rabbles, the maximum speed being about 44 feet per minute, (at one revolution of shaft per minute) and, (2) the successive falls of the ore from one floor to another in fine showers through the ascending heated current of air. At the same time these falls secure a complete turning over of the ore.

I have attempted, by a series of tests, to determine accurately the relative effectiveness of these two agencies. The results obtained were marred by obviously faulty samples, owing to the difficulty experienced in taking samples from the centres without getting them "salted." I do not, therefore, submit the figures, but may state it, as my general conclusion, that the "showers" appear to be almost as effectual in oxidizing as the rabbling.

As a guide to the nature of the product dealt with, to which these remarks and figures relate, the following is the average of several sizing tests of the ore so charged.

Held on	·8	inch screen	4·0	per cent.	22·5 per cent.
"	·6	"	5·5	"	
"	·4	"	13·0	"	
"	·2	"	13·2	"	29·3 per cent.
"	·07	"	16·1	"	
"	20	mesh	7·3	"	48·2 per cent.
"	40	"	13·7	"	
"	80	"	13·1	"	
Through	80	"	14·1	"	
			100·0	per cent.	100·0 per cent.

This product is obtained by passing all of the ore as it comes from the mine through an oscillating jaw crusher, screening through a 1⅛ inch hole trommel screen and passing the over-size from the latter through a pair of rolls.

The corresponding calcines sized as follows:

Held on	·4	inch screen	16·6	per cent.
"	·07	"	19·3	"
Through	·07	"	64·1	"
			100·0	per cent.

Comparing ore and calcines considerable difference is noticeable. This is the result of decrepitation and crumbling. It serves the same as finer crushing and is an aid to good roasting.

With regard to the all important question of costs Mr. Channing informs me that for the year 1902 the average total costs of roasting in the McDougalls was 34 cents per ton. This includes everything but interest on capital invested, viz, direct charges for repairs, power, supplies, tramming ore and calcines, and a proportionate share of all indirect and general expenses. The item of repairs was exceptionally heavy during last year, on account of extensive alterations to the main flue leading to the common dust chamber. This makes the costs for the year abnormally high. The actual operating expenses, exclusive of such special items and general charges are more nearly 23 cents per ton. The cost of crushing, which is not included in these figures, is about 5 cents per ton.

Two furnace-men, with two helpers per shift, run the furnaces, and with some slight alterations in the general arrangement of the plant, which experience has indicated, this number could be reduced or could attend to more furnaces. The principal work is keeping the drop-holes clean and barring down accretions which form on the roofs. Mr. Klepetko introduced scrapers on the top of the rabble arms, but these have not proved altogether successful. The scrapers themselves are soon cut by the crusts and then they seem to have more of a burnishing than a scraping action. They serve however to remove the softer crusts and keep the more inaccessible parts of the roof free from obstruction. These crusts consist principally of iron. They are formed by very fine particles of the iron sulphides igniting in the ascending currents of air, by which they are carried up and thrown in a molten state against the roof, where they adhere. The remedy that suggests itself would be to reduce the draught, or increase the area of the openings. But while the latter is unalterable for a given furnace the former can only be applied at the sacrifice of capacity. The most, then, that can be done is for the attendants to keep the drop-holes and centre holes quite clear.

The power required to drive them is small, being less than one and a half horse-power per furnace.

Repairs at the Highland Boy have been an important item of the working costs. In a large degree this has been attributable to a poor water supply which forms a heavy scale, chokes the passages, and so causes trouble. Apart from the ordinary wear and tear of the driving and feed gears, which is normal, the parts most subject to renewals are the arms. These are gradually eaten away by the acid and sulphurous fumes. Parts in contact with the ore at its hottest, seem to undergo a replacement action, the metallic iron being replaced by pyrite and chalcopyrite. The places where most waste occurs is between the rabbles and the arms. Moisture from the air, and on the top floors, from the ore, is probably condensed on the comparatively cool surfaces of the arms and, with the acid from the gases, becomes a strong solvent and attacks the iron. Were it not for this corrosion the arms would apparently last indefinitely. The rabbles themselves form a very small item of the costs.

The circulating water at the Highland Boy has to be pumped, which adds a little to the costs. The heat carried off by this water is practically negligible being equivalent to the combustion of about 100 pounds of good coal per furnace per hour. Where water is scarce it can, of course, be cooled and used over again.

For an ore in which the sulphur is too low to maintain heat enough for its own combustion auxiliary fire-boxes can be attached and connected with one of the lower floors.

Summarising the chief points in the working of these calcining furnaces which to my mind commend them I would place them in the order of their importance :—

1st. THEIR SIMPLICITY. They are simple in design and simple to run. No need of expert furnace-men, or "born-mechanics," to man them. Ordinarily intelligent labour with good supervision gives quite satisfactory results. There is a minimum of gearing, no elevators with their complications, no forced draughts nor fans with their dust. There are no strains from sudden or unequal expansion and contraction from alternate heating and cooling of parts. And a minimum of parts and patterns for spares need be carried.

2nd. THEIR ECONOMY. They are saving in fuel, labour, and in power, as well as in interest on capital locked up.

3rd. THEIR EFFICIENCY. They produce a good grade of calcines for the purpose required, *i.e.* matte smelting, viz: low surphur, high ferrous with low ferric iron. And they do this with but little waste in flue-dust or otherwise and in quick time.

Some Possibilities of Mining in Canada.

By FREDERICK HOBART, New York.

No ordinary man can, without risk, assume the part of a prophet. It requires a wider knowledge of conditions than most men possess to enable one to foresee the changes which may in a few years affect the course of an industry, the discoveries which may turn the current of trade, or make methods and processes obsolete. It is possible, however to take the conjunction of certain conditions, and to base upon them a reasonable forecast of coming events.

The growth of the mining industry of Canada has been uneven; in which the country is not at all peculiar. It seems inevitable that in all countries, mining, especially of the precious metals, should have its periods of boom and depression. Like the individual mine, the industry generally is now in bonanza and again in borrasca. It is not easy, indeed it has thus far been impossible, to devise any method of equalizing matters and distributing prosperity evenly over the years. The economists who have studied the problem, have generally given it up in despair.

At present matters are, to all appearances, improving. The complications which stock speculation imposed upon some of the best mines in British Columbia, for instance, are in a fair way to be straightened out, and an opportunity will be given to show their real value. The Eastern Ontario mines have found a way to work their complex ores, and utilize the by-products.

While the resources of Canada in the precious metals, in nickel and lead, are important parts of her mineral industry, it seems to an impartial observer that only a beginning has been made on the two branches of mining and metallurgy, which present the greatest possibilities for the future, iron and copper. To take the last named first, some remarkable work has been done in smelting the low-grade ores of British Columbia; but this seems to be really only a beginning, an indication of what may be done in the future. The extent of the deposits of ore and the proximity of fuel, and other materials, point to a much larger production in the future. There can be no doubt that a period of greater prosperity is promised for the copper smelters. The attempt to maintain the metal at abnormally high prices, and, after that policy had broken down, the effort to force a general combination of producers by depressing prices, have both proved unsuccesfful. The copper market is now, for the first time in three years, in a normal condition, where the old law of supply and demand has full affect. The result is seen in the steady rise of prices since the opening of the present year. There is no doubt that the present consumption of the world is fully up to production, notwithstanding recent increases. The mines and smelters which have been able to maintain their production on the basis of 11 cents, can certainly prosper when 13 or 14 cents can be realized. This condition seems likely to be maintained for some time to come; and it will not only keep existing mines at work, but will stimulate the opening of new ones, and prospecting for other deposits. Canada is already an important copper producer, and will, without doubt, improve its position in this respect during the next few years.

In this connection, it might be of advantage to establish an electrolytic copper refinery at some convenient point, so that the product of the western mines could be put on the market as fine copper, ready to be sold at home or abroad, instead of selling and shipping converter bars or standard copper, to be refined elsewhere. The output of the British Columbia mines will soon be large enough to warrant this—if it is not so already. It would seem that this suggestion is worth consideration.

The greatest opportunity for development in the near future, however, seems to lie in the direction of iron and steel production. These industries have, as we know, grown with unprecedented rapidity during the past two or three years. While this growth has been largely due to the energy and success of the Dominion Iron & Steel Company, it looks as if that Company were only a pioneer in the trade, and would undoubtedly have many followers.

Canada has great resources in this line. It is hardly necessary to call attention to the iron ores of Nova Scotia and the east. In the centre, the recent discoveries on the Hutton Range, which I understand are to be described by an expert at this meeting, show that the anticipation of important iron ore deposits in Western Ontario, within convenient reach of lake navigation, are to be fulfilled. The mines of Eastern Ontario have been described by Professor Miller and others. The ores of the coast districts of British Columbia are still to be developed, but they exist in quantity; while other deposits in that Province were well described at the last meeting. The raw material is abundant, and on the eastern and western coasts alike, coal and coke are within reasonable distance. The modern tendency is to carry the ore to the fuel, rather than the fuel to the ore. Every reduction in the distance required for such carriage is a distinct economical gain.

In considering this question of raw materials, I may venture to suggest the hope that Canada, by legislation or otherwise, will be able to avoid the serious economic mistake which is now being made in the United States. The supply of raw materials, as we all know, the life of any trade. The control of the iron ore supplies of the United States is quietly, but steadily, passing into the hands of the United States Steel Corporation, and practically no effort has been made to prevent it. The big corporation is seeking to control the trade, not by absorbing its rivals, so much as by putting them in a position where they will be dependent upon it for the material which they must have, if they are to exist at all. Tne enormous power which will thus be concentrated in the hands of one board of managers can only be appreciated in part now, since a similar condition has never before existed. To repeat, it is to be hoped that in Canada the mistake of allowing the control of a great industry to be held by one corporation will be avoided in time. The economic danger is great enough to overbalance any possible temporary advantage.

From the trade point of view, Canada is exceptionally well placed for a large development in the mining of iron ores, and the manufacture of iron and steel. The home demand is bound to increase steadily with the growth of population and business, and the belief in industrial independence. Beyond this, Canada's position will enable its manufacturers to take the fullest advantage of foreign markets. The eastern mills and furnaces have already begun to sell in British markets to advantage, as well as in those of the United States. They are well situated also to secure a share of West Indian and South American trade, and will doubtless do so before long. On the western coast the establishment of iron manufacture will enable Canada to compete—I believe with success—for the supply of iron and steel to Eastern Asia, and probably Australia also: while there is nothing to prevent the capture of the trade of the entire Pacific Coast. British Columbia has the most important supplies of iron ore and the only good coking coal on the coast; advantages which will surely be realized before long.

The Geological Survey and the Mining Bureaus of the different provinces have thus far rendered aid to the mining idustry in various ways, through not all that has been demanded. The Ontario Bureau has given much attention to the iron ore deposits, and its example might well be followed elsewhere. The encouragement of iron mining and manufacture by economic legislation is a matter outside of this paper, but will doubtless be well considered.

I have not attempted to go into details; the subject is too large for that. I have simply attempted to outline what seem to be the directions in which the Canadian mining industries will grow during the next few years. Iron and copper will, it seems probable, be the chief points of development; but this will not exclude progress in other directions, for which I look, and for which I hope.

Economic Geography.

By JAMES WHITE, F.R.G.S., Dominion Geographer

Geography has been defined by Dr. H. R. Mill as "the science which deals with the forms of relief of the Earth's crust and with the influence which these forms exercise on the distribution of all other phenomena." Economic Geography may be defined as the compilation of the results of the study of this science whether by maps, diagrams, letter-press, or by means of a commercial museum. It is evident that the wide scope of this subject debars its treatment in detail and I, therefore, propose to present a sketch of its possibilities as far as it affects our country, glancing, in passing, at what has been done, what it is proposed to do, and what should be done.

1. *Maps.*—The value of good maps is obvious. If our plenipotentiaries when negotiating the Treaty of Versailles had had even fair maps before them we would now own a large portion of eastern Maine and the boundary line, instead of following Pigeon and Rainy rivers to the Lake of the Woods, would have been carried up the St. Louis to the Mississippi and thence westward on about the parallel of 48°. If the British and Russian plenipotentiaries had attached accurate maps to the copies of the treaty of 1825, the boundary line would unboubtedly be shown as going up what is now known as Behm Canal, to the 56th parallel. Now that the war in South Africa is over and we know the approximate cost, it would be interesting to compare the saving in dollars and cents, that would have been effected if we had had good surveys of the theatre of operations. They would not have prevented the war, but would certainly have shortened it by several months. To the miner and prospector good topographic maps are invaluable. They should show all surface features such as lakes, streams, etc., all artificial works such as railways, roads and buildings, also the relief of the surface either by contours or hachuring, preferably the former. If the rough and unsettled nature of the country prevents the topographer obtaining this detailed information he should, at least, give all possible information respecting the routes of travel.

The Department of the Interior, and Geological Survey, have done a great deal of map-making, the former principally in the North-West Territories and "Railway belt" of British Columbia and in the Dominion as a whole, while the operations of the latter have extended over nearly the whole of the mainland of Canada. Other departments have published maps but as all, or nearly all of them, have been reproductions—usually on a larger or smaller scale—of those produced by the Interior, or Geological Survey, they may be ignored. It is note-worthy that, with the exception of one Manitoba and a few British Columbia and Yukon maps none of these sheets show what I have emphasised as of great importance viz, relief of the surface.

While the number and accuracy of these maps—considering the methods that the topographer and geographer have, perforce, used—are worthy of all praise, there is no use shutting our eyes to the fact that undue delay in publication has occured, and is occuring, and that geographical information which, if published, would be invaluable to the mining and other interests of the country, is locked up in note books and plotting sheets. No one, not conversant with the methods that the geographer in Canada is forced to adopt in compiling topographical sheets, can understand the disadvantages under which he labours, disadvantages which result in the needless expenditure of money and in loss of time while, geographically, the results are far from satisfactory. I can not do better in this connection, than quote from a memorandum by Dr. Dawson, late Director of the Geological Survey.

'The difficulty met with in the compilation of such maps arises largely from the number of sources from which information must be sought rendering it practically impossible for the compiler of a given map—probably pressed to complete his work at a certain date—to consider, collate and familiarise himself with all. Thus, in the North-West Territories, within a comparatively limited district, surveys made under the following branches may have to be included—Topographical Surveys and Timber & Mines branches of the Department of the Interior, Geological Survey, Department of Railways, Indian Department etc. In the older provinces this is additionally complicated by surveys under Provincial Government auspices, surveys by the Public Works

Department and by railway companies, charts of the coast by the Department of Marine and the Admiralty and other minor surveys not necessary to particularise. All of which have to be consulted for recents additions and changes before maps with any claim to represent the actual state of geographical information can be drawn.'

The remedy for this state of affairs is admirably outlined in the recommendation of the Civil Service Commission of 1892 as follows:—

"Your Commissioners find that maps for various purposes are prepared in several Departments and, by the evidence produced, it is shown that differences frequently occur in maps of the same district when issued by more than one Department. To prevent this, and to promote accuracy and security, it is recommended that a special cartographic branch be created and that the duty of this branch of the public service should be to issue reliable maps of the various parts of the Dominion.

2. *Museum of Economic Geography.*—Although the establishment of such a bureau in Canada can not be looked for in the immediate future, a short description—summarised from an article by Mr. V. V. Branford, in the Scottish Geographical Journal—of a similiar institution, the Philadelphia Commercial Museum, is of interest. In 1893, Dr. W. P. Wilson, now Director of the Museum, conceived the project of retaining some of the exhibits of the Chicago exhibition to form the nucleus of a permanent collection of the World's industrial projects and persuaded the city of Philadelphia to vote $10,000 for this purpose. With this modest sum as a basis he founded an institution that covers upwards of 16 acres and has an annual income of $200,000—$115,000 from the municipality and $85,000 from other sources—which has 100,000 correspondents and agents in all parts of the earth and which practically complies a systematic catalogue of the world from the American exporter's point of view.

It has three main departments (1) The Museum proper (1) Laboratory (3) Bureau of Information.

The collections in the Museum proper are, in a general way, divided into Geographical collections where the articles are grouped according to country of origin and into Monographic collections of different varieties of the same material, of wools, cottons, minerals, oils, dye stuffs, etc. which are augmented and renewed from time to time. As the aim and object of the Museum is essentially commercial, full details as to the cost of production, wholesale and retail prices cost of transportation, statistics of imports and exports, information respecting the financial standing of the principal firms in the foreign cities etc. are furnished to subscribers.

It has also endeavoured to improve the teaching of Commercial Geography in schools and colleges by the distribution of type collections of produce accompanied by printed and pictorial descriptive matter illustrating commercial processes and products. Teachers and students can visit the Museum at regular intervals for study under the officials. The collections are open to the public; general reports and more important items of commercial news are distributed gratuitously and it also answers, without charge, the thousands of domestic and foreign letters of enquiry. For $100.00 a year it also gives a regular service of information respecting current commercial events, the world over.

In the Laboratory, chemistry and the microscope are utilised to determine the amount of cotton in "all wool" goods, of copper in an ore, etc.

The principal sources of information are as follows:—

(1) Trade journals of various countries, some fifteen hnndred in number, from which the principal facts are culled and indexed by the card system, any matter calling for immediate attention being brought to the notice of the manrfacturers interested therein.

(2) Consular and other official reports of the United States and foreign governments which are treated in the same way as the trade journals. As the results of reporting to the Museum are manifest, it is said jestingly, that American consuls sometimes report to Philadelphia and ignore Washington,

(3) Special representatives who study trade conditions in foreign countries in the interests of American exporters and endeavour to bring foreign governments and dealers into touch with the Museum.

3. *Economic Atlas.*—The Department of the Interior proposes to

undertake, as soon as the results of the last Census are available, an Economic Atlas on much the same lines as the Atlas published by Finland—a unique publication, no other country in the world having attempted anything as comprehensive as the Finnish work. As the necessary information is not available we will not be able to undertake anything as detailed or elaborate as the Finnish atlas but do propose to present a diagrammatic summary of the domestic material assets of our country. It will include:—

(a) Topographical map of Canada on a scale of 35 miles to the inch showing the principal mineral occurrences, forest, agricultural and dairy resources.

(b) Geological map of Canada—scale 100 miles to the inch.

(c) Hypsometric map showing elevation of land surface.

(d) Map showing telephone and telegraph lines, and canals, with statistics of mileage of telephone and telegraph lines and of tonnage of freight and vessels through, size of locks, depth on sill, length, etc. of canals.

(e) Meteorologic maps showing isotherms and isobars for months and year, snowfall and rainfall.

(f) Map showing limits of trees, shrubs, cereals and general culture.

(g) Diagrams illustrating population statistics, for census years, of number, density, proportion of sexes, population according to age, sex, urban and rural, civil state (married, unmarried, widows, widowers, and divorced); degree of education, vital statistics and population by profession and origin; financial, as revenue, expenditure, exports and imports—with special diagrams for principal articles of production and export—and trade per head as compared with other countries; diagrams illustrating growth of industries which have made great advances as mining, manufactories and agriculture; navigation, tonnage, freight, number of passengers carried and vessels entered at principal ports.

It is desirable that a water-power map be included but the available information is of too fragmentary a nature to justify the attempt. In the Finland atlas the position of the falls and rapids is indicated by a red line the length of which is proportional to the fall, and by a green circle of area proportional to the horse-power. The importance to the miner and manufacturer of data relating to the discharge and fall of streams can hardly be overestimated. Many thousands of dollars wasted in installing plants where sufficient power is not available might have been saved if the necessary information had been obtainable. In addition to the commoner uses for water-power its use in connection with the production of electricity for electro-chemical processes is of increasing importance. In coal-less provinces, like Ontario and Quebec, we must look for its substitute to the innumerable streams that descend in a series of rapids and falls from the great Archean plateau that forms the northern portion of their area and which carries what is probably, the greatest spruce forest in the world. The value of water-power will undoubtedly be much greater in the future than in the past, and will determine the localisation of great manufacturing centres. As the water supply depends entirely upon the rainfall it is evident that a study of the latter in connection with the hypsometry of the country will be of great importance and in this connection additional meteorological observers will be required in the more thinly-settled districts.

When in Washington last fall, I investigated the methods used by the hydrographer, Mr. Newell, and found that he has succeeded in securing a maximum of result at a minimum of cost. For instance, on the smaller streams if there is no suitable log in place, a tree is felled—usually near a road bridge—with one end in the water and the other on the bank, a flat surface cut on one side and divided into a scale that represents feet and tenths of vertical height. As the logs lie at a considerable angle with the vertical, the divisions are some distance apart which renders it easy for unskilled observers to read. Daily readings are taken by an observer—usually a store-keeper or farmer who lives in the vicinity, or a school teacher whose route leads past the observing station. The observer receives $35.00 to $60.00 a year and, once a month, fills in the results on cards supplied for the purpose, which are then mailed to Washington. When establishing the station the stream is cross-sectioned and the velocity measured with a current meter. With this data and with additional measurements of velocity taken at different stages of the water, the discharge can be readily calculated. For large streams gauges of a more expensive and more elaborate pattern are used.

Hypsometric maps are valuable as the form of the land determines the direction and strength of the wind that blows over it and the abundant rainfall, or lack of it, in any district, is the direct result of the guiding action of the elevations and depressions of the surface. Professor Saunders of the Experimental Farm informs me that in the North West he finds the matter of altitude has much influence—sometimes more than latitude—in regard to the trees and shrubs under trial.

Diagrams showing population and other statistics gathered from the Census, Trade and Navigation, and other reports, will show at a glance the distribution of every condition that is dealt with and enable the reader to follow, decade by decade, the progressive development of the country, and to study for each census the relation between the various conditions.

Among the points that will be specially emphasised in the Economic Atlas are :—The immense mineral wealth, as the coal-fields of the Maritime Provinces, the North West Territories and British Columbia, the gold-fields of Nova Scotia, British Columbia and Yukon, the asbestus of Quebec, nickel of Ontario, silver, lead and copper of British Columbia, etc.; that our mineral production has increased from $13,221,225 in 1886 to close upon $70,000,000 in 1902; that comparing on the basis of population, our external trade is $13 per head, three times that of the United States; our exports of manufactures, one and a half times as great; that we have more miles of railway per head, than any other country in the world, and stand eighth as regards total mileage; that, in the last ten years, our trade has increased faster than that of any other country, viz. 90 p.c.; that, in the same time, the balance of trade against us—the excess of imports over exports—has decreased from upwards of 8½ millions to less than half a million, and the assets of our chartered banks, have increased from 292 millions to 625 millions; that—to take one item of dairy products in which we have made great advances—our exports of cheese increased from 49 million pounds in 1881 to 196 millions in 1901, while in the same period the exports of the United States decreased from 148 millions to 40 millions; that barley, oats, wheat, and all hardy vegetables have been grown at Dawson, only 150 miles from the Arctic Circle; that the total imports of wheat into Great Britain aggregate 160 miilions while our surplus for exportation was 10 millions in 1900, 30½ millions in 1902, and in a few years will be sufficient for the needs of the mother country, thus making Canada truly "the granary of the Empire."

At first sight, the great development of the arable land in our North West may appear to have comparatively little effect on mining, and to be of comparatively little interest to mining engineers, except as patriotic Canadians, but settlement brings railways with greatly increased facilities for the transportation of mining supplies, and of the product of the mine, while the mines furnish a valuable local market for the farmer and stock raiser.

At the present time three railways, the Canadian Northern, Grand Trunk Pacific, and Trans-Canada are either actually under construction or have engineers in the field locating transcontinental roads that will cross the mountains by, probably, the Yellowhead, Pine and Peace River passes, all very much lower than any pass traversed by similar lines in the United States. The Yellowhead Pass line will, in all probability, traverse the Cariboo country. What this means is best illustrated by the remarks of Mr. Hobson, Manager of the Consolidated Cariboo Hydraulic Mining Company, at a recent meeting of the Provincial Mining Association of British Columbia. He said: "During the time we have been engaged on construction work we have used as high as 150,000 lbs. of oats, 160,000 lbs. of hay, and 60,000 lbs. of beef. This is the farm produce consumed by one mine. Now, gentlemen, what would two or three hundred such mines do for the farmer? We have made expenditures in cash of from $60,000 to $70,000 annually for miner's wages; $25,000 to 35,000 for teamsters for hauling provisions from Ashcroft to the mines, and even as high as $50,000 during the progress of development work; $30,000 to $60,000 has been expended annually in Victoria and Vancouver for miscellaneous stores and provisions, including hardware. In addition to the above we consume annually explosives costing from $30,000 to' $50,000—all purchased from Victoria manufacturers.

" Every pound of goods that we get delivered at the Consolidated Cariboo Hydraulic mine is drawn a distance of two hundred miles and costs 5 cts, or $100 a ton. We of course suffer for lack of railway transportation facilities; but I think transportation facilities will eventually come. The mountain regions lying to the east of the Cariboo and Horsefly districts are now known to contain extensive bodies of argentiferous galena and copper ores, the same as you have in the Kootenay and Slocan country. Railway transportation facilities are required to encourage and hasten the development of the mineral industry of the Province, and railways will no doubt be built as soon as soon as it is known that business will warrant their construction."

We are on the eve of the greatest period of expansion and development that the world has ever seen; 25,000 Americans crossed the border last year, and 50,000 will cross this year, despite the endeavors of agents of United States railways and land companies; the tide of European immigration that has hitherto poured into the great republic to the south of us will now undoubtedly turn Canada-wards and the marvellous development of the American West and the North-West will be duplicated in our Territories. In the United States, the territory of Oklahama increased from 78,000 in 1891, to 398,000 in 1901, and we have room in our southern territories alone, for nine Oklahamas.

In conclusion I wish to enter a mild protest against the popular idea that a geographer is a map-maker and nothing more. A proper conception of his functions is admirably outlined by Dr. A. J. Herbertson in his paper on " Geography in the University." (Scottish Geographical Journal for March, 1902).

' A geographer is at once a patriot and an internationalist, keenly alive to the necessity of stimulating the full development of local activity and resources, yet world-wide in his outlook and sympathies. The one is essential to the other, for each part of the world is now so closely linked to every other part, that healthy progress in one is favorable for all. The geographer is a student of the world of peace as well as of the theatre of war—the exponent of the environment to be dealt with in any venture, commercial or military, political or missionary. He must have time to travel, and in return, the fruits of his observations and his thoughts should be given to his pupils and to the world. It seems to the writer that one of the most important duties of the geographer is to show forth sympathetically the conditions of other countries to the younger generation in the university, and on occasions to the public, and thus help to remove prejudice and foster good feeling which is so essential for the rapid harmonious development of this complex world in the twentieth century.

Notes on the Gold Ores of Western Ontario.

By Mr. Charles Brent, Rat Portage.

The gold fields of Western Ontario are situated on what is regarded by geologists as the oldest portion of the earth's crust now exposed.

The formations are entirely Archaean and are two in number viz. the Laurentian and the Huronian, the latter being subdivided into the Couchiching and Keewatin series. The term Laurentian is used by Canadian geologists to designate in a petrographical and structural sense the crystalline, generally acidic, granitic or gneissoid rocks underlying the Huronian.

The Huronian of Western Ontario, in its lower series the Couchiching, consists wholly of sedimentary shallow water deposits of clay and clayey sands now almost wholly converted into grey and brown gneisses and mica schists, but in places being merely consolidated into sandstones showing little or no alteration.

The upper or Keewatin series is largely composed of eruptives and their products with important sedimentary deposits now occurring as conglomerates, quartzites, grits, breccias, graywackes, slates and limestones.

The lower Archaean occurs in large isolated areas, more or less surrounded by the schists of the upper Archaean, the latter forming a rough net work around the Laurentian areas.

The Huronian series dip away at high angles in every direction from the Central Laurentian bosses forming syclinals between the granite areas and now showing sections by which the geological history of the region has been worked out.

The whole mass of the western Huronian series was once floating on a viscous granitic magma which, under the varying weights of the Huronian strata, or from some deep seated internal force, swelled up into great bubble-like domes, allowing the floating strata to sink into the spaces between. As the domes pushed upwards, the surface strata were stretched, fissured, sheared, and contorted, according to their position with regard to the rising masses which by friction with the colder strata had their outer cooling surfaces drawn into a sort of rough parallelism with the shear planes of the outside rocks, thus forming the gneissiod margins which almost invariably surround the granitic masses. At the same time the margins of the granite masses were affected by the contact with the basic schists becoming themselves more basic and darker in color. Felsitic dykes were at the same time injected into the fissures of the Huronian, formed by the stretching and fracturing of the colder rocks.

It must be supposed that these granitic magmas, though possessing fluidity, were only hydrothermally fused, since all along the edges of the contract, angular fragments and slabs of basic Huronian rocks, readily fusible at the melting point of granite at a dry heat, are found floated off into the granite with their edges not even rounded by the heat. Later bosses of finer grained granite break through both Laurentian and Huronian areas and throw out felsitic dykes into each formation. A still later eruption of very fluid felsitic matter, which may have been formed by a sort of a liquation process from some of the older eruptions, must be assumed to account for some of the fine grained felsitic dykes which occur occasionally along the lines of contact of the older formations, and penetrate fissures of almost capillary fineness in these rocks.

From the great magnitude of these domes of granite, and from the steep dip of their synclinal gneissoid margins, which correspond to the dip of the Huronian formations lying on their sides, it may be inferred that these Archaean mountains were comparable in height to the greatest elevations of the present day. Lawson estimates the thickness of the Huronian rocks at 50,000 ft. and it is thus probable that the summits of these oldest of earth's mountains rose many miles above the present level.

Dynamic disturbances of post Archaean times have apparently been rare in this district, and are confined to the injection of a few *diorite* dykes, and the fissuring and faulting of the rocks in the immediate vicinity of these. It must not be assumed from this statement that there has been no movement in the rocks during post Archaean times.

The elastic character of the quartz in most of the ore deposits, and the shattered pyrites, often of different ages, constantly occurring in the veins, show that movements have taken place which, however, are probably rather of secular than of dynamic character.

By the process of denudation which culminated during the glàcial epoch, these great elevations have been reduced to an approximately level plane, lying about 1200 ft. above sea level, which presents at the present day a most interesting section through the base of this group of ancient mountains. This plane is diversified by numerous basins scooped out of the softer rocks, which are now occupied by the complicated lake system of the district.

It may be noticed that the chains of lakes conform generally to the strike of the Huronian rocks, which is approximately that of the direction of the glacial flow.

Post glacial changes have been very slight over the entire region as is evidenced everywhere by the freshness of the glacial striae and by the existence all over the distinct of brightly polished surfaces of rock which are just as smooth to-day as they were when the retreating ice sheet left them bare to the sky. This brief review of the geological history of the district will serve to make plain many particularities of the ore deposits and ores of this oldest of all the gold fields.

The disturbances of the Archaean period alone are responsible for the general geological arrangements we find at the present day and also for the folding, shearing and formation of the fissures which by subsequent circulation of hot and cold waters have been filled with the quartz and other minerals, which form the ore deposits of Western Ontario.

The levelling of the Archaean mountains which took place through the long ages preceding the glacial epoch was completed during that period and the whole mass of decomposed material swept away to the south and west to be distributed over half a continent, leaving only the solid unaltered bases of the mountain group.

This sweeping away of the debris of ages has rendered the ore deposits of Western Ontario unique in many respects, among which may be noted the following:—

1st. The general levelling has left no great elevations. There is consequently practically no post glacial drift, and the ore deposits are in plain sight. What is practically a deep level section of the ore body is laid bare with all its characteristics and, since it is axiomatic in mining, that "as the length is so is the depth," the underground behaviour of these ore bodies can be predicted with almost absolute certainty.

2nd. The contacts between the granites and traps, as the Laurentian and Huronian formations are commonly called, are always in plain sight, and since it has been established by actual work that these contacts are in some way connected with the presence of gold in the ore-bodies in the vicinity, a useful guide is always at hand in exploring new areas.

3rd. There is practically no surface decomposition or surface enrichment to be met with in the entire district. A few feet of sinking, as a rule, reveals the character of the ore, and that character is maintained in depth.

4th. There is no "water level," such as is commonly met with in other mining districts, below which decomposition ceases and the ore changes in character. If an ore is found to be "free milling" on the surface it will retain that character to an indefinite depth.

5th. The solidity of the rock in this district is such that very little timber is required, and although shafts are commonly sunk for hundreds of feet within a few feet of the shores of great bodies of surface water, no trouble has been encountered from an excess of underground water.

6th. The rocks of this district are the hardest known to the mining world, and more steel is used both in mining and crushing than in any other part of the world.

7th. The absence of any considerable elevations, and the consequent lack of rapid streams, coupled with the fact that there is no loose material except glacial drift, would seem to preclude the probability of any areas of placer ground being found, unless the streams, which must have flowed to the south, from the retreating southern edge of the ice sheet, during the close of the glacial period, have concentrated the gold contents of some of the terminal moraines.

As have been mentioned above the most promising auriferous deposits occur on, or near, the contact of the Laurentian and Huronian formations, but gold has been found as well in veins in granite areas far removed from any contact, and bunches and segregations of gold bearing quartz are found everywhere in the Huronian schists with no apparent connection with any later eruptive.

A number of interesting occurrences may be cited to show the wide spread diffusion of the precious metal in this district and the varying character of the auriferous deposits.

On Gold Brook, near the Mattawan River, a number of locations have taken up on a band of fine grained gneiss with sparsely disseminated grains of iron pyrites, which carries gold throughout, from a trace to 50c. per ton. This deposits is nearly half a mile wide, and several miles long, and although the gold content is too low for profitable working, the occurrence must be regarded as highly interesting from a theoretical standpoint.

At the Hammond Reef, a band of shattered granite, with quartz filled seams, has been found to carry a workable amount of gold over a width of 300 feet and a length of some miles.

On Shebandowan Lake a number of very coarsely crystalline dykes of porphyry carry from a trace to $20.00 per ton.

On Eagle Lake a band of schistose granite, thirty feet in width, is being actively worked with satisfactory results.

A large number of locations have been taken up on felsite dykes, many of which carry gold *per se* as well as in the fissures now filled with quartz, which were produced by the shrinkage of the dyke rock in cooling, or by subsequent movement along the line of weakness, which caused the primary dyke fissure. Among these may be mentioned the Bully Boy on Camp Bay. The Champion, near Rat Portage, No. 2 vein at the Big Master, on the Manitou, and the Sakoose, in the New Klondyke, all of which have proved to contain workable amounts of gold.

True Fahlbands, or belts of schist, impregnated with pyrite and other sulphides are unknown in the district, but numerous bands of pyritous schist with intercalated seams of quartz are to be found in the country. These generally contain lenticular bodies and stringers of quartz, and are rather to be regarded as bedded deposits; although generally classed as Fahlbands. Among this class may be cited the Scramble, near Rat Portage, the Flint Lake, on Flint Lake, and the Little Bobs on Denmark Lake. Bedded, or lenticular, or segregated veins are the usual form of ore deposits in schistose rocks, and these occur in great variety in Western Ontario.

At the Sultana, a series of great lenses in sheared porphyritic gneiss have produced a large amount of gold. At the El Dorado, on Eagle Lake, a bedded deposit in sheared granite is being developed with satisfactory results. At the Big Master, a bedded vein in chloritic schist has produced a large amount of gold. The gold Hill veins, the Black Jack and Golden Gate veins, in hornblende schist, have been worked with satisfactory returns.

The Olive, in the Seine River District, lying in a bed of schistose diorite, also auriferous, has produced a good deal of gold.

The Golden Horn, on the Lake of the Woods, in chloritic schist, is being actively developed with satisfactory results. The Wendigo, on the Lake of the Woods, is working a bedded vein in a band of pyritous hornblende schist which carries a workable amount of gold.

The Triggs, Reliance, Gold Panner, Virginia, Cameron Island, are among many others worked on bedded veins in schistose formations, with more or less success.

So called true fissure veins are numerous in the granite areas, but as might be expected, are comparatively rare in the schist. The Ferguson, Foley, and Lucky Coon, on the Seine River, the Golden Eagle, on Eagle Lake, and the Nino, in the Deer Lake country, may be cited as notable examples of this class of deposit in granite, and the pebble vein at Gold Hill Mine, and the Jubilee vein, on the Manitou, may be cited as examples of true fissures in schistose formations.

Of contact veins no typical examples have been worked, although many such are known. The Mikado vein and the Black Eagle each cross a contact between diabase and granite, and since, by longitudinal faulting in each case, one wall of the vein is granite and the other diabase for a short distance, these veins are in part true contact deposits.

It may be noted as a curious feature that the richest ore in the Mikado vein lies in this zone of contact, while the leanest ore in the Black Eagle lies in the corresponding position.

As to the primary source of the gold in these deposits, not enough data are at hand to enable one to generalize with any degree of certainty, but from the fact that many of the felsite dykes carry gold *per se*, and that no gold has been found in the Couchiching series, and but rarely in the sedimentary members of the Keewatin, and that eruptive contacts have been proven to be favorable to the presence of gold, it would seem that the gold came up from deep seated sources, both with the Huronian eruptions, and the later Laurentian granites, to be distributed in its present situations with the quartz and accompanying minerals by the circulation of water under unknown conditions as to time, temperature and pressure.

As to the character of the ore, it may be noted that in all classes of deposits, the gold, whenever found in workable amounts, is invariably associated with quartz in some form, and with the sulphides of iron, copper, lead and zinc, and that no complex minerals, and but few rare minerals are present.

Gold, if present in workable amounts, is, to a great extent, "free milling," and it may be taken as an axiom in this district, that if an ore does not show gold in the pan it is economically valueless.

As to associated minerals, it may be noted that *Iron Pyrite* occurs in every gold ore in the district, and that as an indicative mineral, it is valueless.

The same is true of Pyrrhotite, which is commonly abundant in the pyritous schists. When an ore contains "free" gold the iron pyrite invariably contains gold, the pyrrhotite almost never.

Copper Pyrite in the ores of the Black Jack, Wendigo, Mikado and Black Eagle, is invariably associated with high values in gold, while in the ores of most of the other veins of the district its presence means nothing favorable or otherwise.

Galena is invariably associated with high values in gold in the Sultana, Mikado, Golden Horn, Golden Star, Olive, Foley, Champion, Treasure, and Big Master mines.

Zinc Blende is of the highest value as an indicative mineral in the veins of this district, and wherever quartz is found with disseminated zinc blende, it is safe to say it is rich in gold. The richest ore in the Foley, Golden Star, Olive, Sultana, Champion, Golden Horn, Sakoose and Big Master, as well as in the veins in Eagle Lake, is invariably associated with the sulphides of zinc and lead, although these minerals, in most cases, carry little or no gold *per se.*

The rare sulphide of Bismuth, Bismuthinite, is abundant in the ore from the Mikado vein, and is sparingly found in the other veins of the vicinity. It is invariably associated with high gold values in the Mikado vein, and possesses no significance in any of the other veins in which it occurs.

Mispickel, and Arsenical and Antimonial sulphides are rare, and traces only of tellurides are met with, the only exceptions being the Huronian vein, in Moss Township, which produced very fine specimens of sylvanite, and in the Gold Creek vein, on the Lake of the Woods, which, in a narrow pay shoot, carries the rare silver telluride Hessite.

Leaves of native copper are comparatively common in the gold ores of the district, and particles of native silver, and of native platinum, have been found associated with gold in several veins on the Lake of the Woods. Molybdenite is commonly found in gold bearing veins but possesses no significance as an indicative mineral.

As indicative minerals, the sulphides range in value as follows: 1. Zinc Blende. 2. Galena. 3. Copper Pyrite. 4. Iron pyrite.

As may be gathered from the foregoing notes, the gold ores of the district may be regarded as "free milling," and experience has shown that from 70 to 90 per cent. of the total gold contents of the ores may be obtained by simple battery amalgamation, and that a satisfactory percentage of the remaining values may be obtained by subsequent concentration and chlorination, or cyaniding, or by direct cyaniding without previous concentration.

The "free milling" character of the ore has been retained in depth, and from the considerations presented in these notes, it is to be expected that these characteristics will be permanent to any depth, and since from a geological standpoint there is no reason why the deposits themselves may not run to as great depths as are practicable to mine, it would seem, that in spite of many disastrous failures up to date, that as soon as the era of "wild catting" and stock jobbing schemes passes over, that money and common sense will ultimately make a profitable, permanent mining industry in Western Ontario.

There is no district in the world where so many classes of gold bearing deposits may be met with as in this, and nowhere else is there such a wide spread diffusion of the precious metal, and although it is not to be expected that all of these gold deposits can be made to pay, it is to be expected that some of the best of them under the favorable conditions as to accessibility, climate, water, fuel and water power, may be made profitable mines when ample capital and experienced management are brought to bear upon them.

Electrolytic Production of Metals with Special Reference to Copper and Nickel.

By Mr. Titus Ulke, Sault Ste. Marie.

(*Communicated.*)

Permit me to thank you for your kindness in sending me copies of discussion relative to "The Electrolytic Production of Metals, with Special Reference to Copper and Nickel," which you published.

I have only recently returned here from a nine-weeks' trip, inspecting the copper mines and smelting works of British Columbia, Washington, California, Arizona, and Sonora, Mexico, and have therefore not had leisure to write you before.

As regards Mr. Koehler's reply to my last stricture, I need hardly call attention to the fact, *re* 1, that Dr. Schnabel's classification is logical, while Mr. Koehler's is not, his explanation to the contrary notwithstanding.

Re 3. Mr. Koehler is finally compelled to admit my structure, viz., "that the chloride method has, to say the least, not yet attained commercially practical prominence," and that there are grave difficulties in its way not encountered in the ordinary sulphate method of electrolytic refining.

Re 7. As the technical press and leading experts view my process with unqualified favor, and as the novel features thereof are covered by broad patents, or pending applications for same, I need not further discuss the merits of my process.

The printed discussions, I take it, has fully borne out the merits of my contention and friendly criticism of Mr. Koehler's interesting paper, which I could not well pass over without noting the few inaccuracies cited.

Mining Possibilities of the Canadian Rockies.

By BERNARD MACDONALD, Spokane, Wash.

INTRODUCTION.

As its title indicates, the object of this paper is to show possibilities of the Canadian Rockies, as a mining field.

The scope of mining, referred to here, is intended to cover the mining and production of the precious metals only. And by way of preface to the general discussion of this subject, the important part that a large stock of metallic money plays in the development and commercial greatness of a country, is noted, and, in this connection is also noted that the present money circulation of Canada is inadequate, and the means of obtaining, and the advantage of possessing a larger money circulation are suggested.

It will be shown by inference that in the region of the Canadian Rockies, the mineral resources of which, are as yet, undeveloped, lies the source of an enormous supply of the money metals. In proof of this, reference is made to the enormous production of gold and silver from such portions of the Rocky Mountains as lie within the other countries of North America, and the deduction is made, that there being no general difference between the geological structure of the portions of this range of mountains within such countries and the portions of them within Canadian territory, equal production should result from the latter portion when explored and developed to an equal extent.

A large production of precious metals within a country is an object of great national importance, these metals furnishing the home supply of gold and silver coin, which is recognized as the money of ultimate redemption in the monetary systems of the civilized nations. All other forms of money come under the head of the promissory or token class, and their recognized, or negotiable value, is based on the probability of their ultimate redemption in standard coin or bullion, at their face denomination. Gold and silver coin, or bullion is, therefore, to be taken as the basis of all current standard money. The proportional volume and soundness of the monetary system of any nation, will be in direct ratio, other things being equal, to the size of the metallic base upon which it rests. And, it is a generally recognized fact that the volume of the business that any country is capable of sustaining, is measured by the volume of the stock of current money in that country; while the amount of successful business transacted in a country, is the true measure of its prosperity and commercial greatness.

These premises being true, it follows that the prosperity of any country is in direct ratio to the volume of metallic money, or money metals, constituing the base for its currency circulation. And, as prosperity ministers best to the wants, and otherwise contributes to the happiness and greatness of the people of a nation, it is the plain duty of governments, acting through wise legislation, to provide means and measures, under the operation of which, the people may accumulate a large volume of metallic money.

If the industrial conditions of Europe, during the closing years of the 15th Century, when the stock of gold and silver money then existing in that contitnent, is estimated to have been only $193,000,000, be contrasted with the industrial conditions at the present time, when the stock of gold and silver is about 20 times as great, the improved conditions that now exist will go to prove the foregoing conclusions. Moreover, on careful investigation, I think it will be admitted, that the improved industrial condition and modern prosperity of the world in general, is due, in a very large measure, if not entirely, to the influence of the money metals that have been mined, coined, and put into circulation since the close of the 15th Century.

Illustrating the valuable effect a prosperous mining industry has on a country, the following reference to the results in the United States for the year just ended, is quoted:

To make clear this wonderful product of things under the earth, this illustration may be given: If the wealth of the nation was wiped out, if its farms were destroyed, its manufactories annihilated, its railways torn up and cast into the sea, its ships sunk—if every vestage of the nation's wealth were to perish and leave only the mines—the mining industry at the rate of last year's (for 1902) return would rebuild the entire structure in 70 years, for its production in that single year, $1,360,344,147, which including the coal, iron and petroleum was sufficient to have more than paid the national debt. This statement could not be made of any other country on the earth.

THE PRINCIPAL GOLD AND SILVER MINING FIELD IN THE WORLD.

The main source of the precious metals mined within the last three and a half centuries, has been the Rocky Mountain Regions. The portion of these mountains within Mexico will be referred to as Mexican Rockies, within the United States as the American Rockies, within Canada, as the Canadian Rockies.

The history and progress of mining on this continent from its beginning to the present time, may be briefly summarized as follows:

Early in the 16th Century, shortly after the discovery of America, the regions of Mexico, and the Central and South American countries penetrated by the Rocky Mountains, were invaded by the Spaniards, who found large stores of silver and gold in possession of the Aztec and Indian Aborigines of these countries. After these people were conquered, and their stores of precious metals confiscated and shipped to Spain, the invaders began to search for the mines from which these metals were obtained. These were found scattered through the mountain regions of these countries. The work of mining was then begun by the Spaniards, who pressed into slavery for that purpose, the conquered Indians. From that day to this the output of the precious metals from these countries has been continuous, increasing or diminishing, from time to time as the domestic conditions of the countries permitted, and as the genius of the inhabitants was able to solve the problems of economic production.

The total production of gold and silver from these countries from that time to the present, is enormous. The coining value of these metals produced in Mexico to date is estimated by statisticians to be about $5,500,000,000. A similarly enormous production has been obtained from the Rocky Mountains in the other Spanish American countries, but for the purpose of this paper, it will be necessary to consider, only, the production of the neighboring countries in North America through which the Rocky Mountains run.

As stated, Mexico has produced in the past 350 years, the sum of $5,500,000,000, which makes an average annual production of $15,714,285, during that time. As there are about 1750 miles, in length, of the Rocky Mountains within that country, the average production for each such mile of these mountains, was $3,142,857. The annual production seems small if compared with modern results, but when the small population of that country at this beginning, and for years afterwards, the total lack of modern facilities for mining, the absence of mining and metallurgical knowledge, and the insecurity of property rights, that have existed at times during this period, are fairly considered, it will seem as much as could reasonably be expected. At this place, it will be interesting to note that the coining value of the gold and silver produced in Mexico, during last year (1901) amounted to a total of $65,479,940, taking an ounce of silver as $1.00. This, compared with the average yearly production of the preceding 350 years, shows an increase of 400 p.c. and proves in the light of past production the inexhaustible mineral resources of the mines of the Mexicen Rockies.

PRODUCTION OF GOLD AND SILVER IN THE AMERICAN ROCKIES.

For 300 years after the production of gold and silver had commenced in the Mexican Rockies, nothing was done towards the systematic exploration of the northerly extension of this chain of mountains, within the territory now occupied by the United States. After the discovery of placer gold in California in 1849—53 years ago—numerous expeditions of gold seekers started from the Eastern States and other sections of the world, for California. At this time, the intervening plains, then the "Great American Desert," now the most fertile country in the world, lay between, swarming with hostile bands of Indians, while beyond these plains towered the snow-clad Rockies, pathless and unknown except to the fierce tribes of Indians who contested the advance of this invasion. These natural obstacles were soon overcome by the determination of the gold seekers, but when they reached the mines, they knew nothing about mining or metallurgy and could not even recognize the common ores of gold and silver. In addition to this lack of technical knowledge, the regions were inaccessible, for there were no roads or even trails. Under these conditions, progress was at first slow. As years went by however, mining and metallurgical knowledge was being gradually acquired and crystallized into science, in the hard but efficient school of practical experience. Transportation facilities were improved, mining machinery invented, and the production of the metals grew accordingly. From such a beginning, 53 years ago, the production of gold and silver from the American Rockies, increased year by year until it reached a coining value of about $155,000,000 in the year 1902. This amount brings the total production up to $4,500,000,000 for the 53 years since the commencement of mining, being an average annual production of nearly $85,000,000 or $3,461,539 for each mile in length of the American Rockies.

It will thus be seen, that from a country in which the production of the precious metals was practically nil, 53 years ago, the United States, in its production of these metals for 1902, has surpassed that of every other country. This has been made possible only by the vigorous exploitation of that inexhaustible source of gold and silver—the Rocky Mountains.

PRODUCTION OF THE CANADIAN ROCKIES.

The Rocky Mountains, in their northerly course, after passing through the States of Montana, Idaho and Washington, enter into the Provinces of British Columbia and Alberta in Canada, and extend northward through these provinces, and the Yukon and Northwest Territories till they pass into Alaska, or terminate on the shores of the Arctic Ocean, in the neighborhood of the mouth of the Mackenzie River. Within Canadian territory, these mountains have an approximate length of 1600 miles, by an average breadth of from 500 to 800 miles, and possess the same general structural features, as they do in their southerly extension into American and Mexican territory. For this reason, it is fair to assume, that as already indicated, the Canadian

Rockies will yield a quantity of the precious metals equal to that produced by them in American or Mexican territory—mile for mile of their length, when equally developed.

The production, therefore, that may be expected of the Canadian Rockies, in the future, may be seen from a study of the following table :—

COUNTRY.	Miles of Rocky Mount'ns	Av. production per mile.	Total production
Mexico	1700	$3,142,857	$5,500,000,000
United States	1300	3,461,538	4,500,000,000
Canada	1600	103,750	166,000,000

In extenuation for the unfavorable contrast shown by the production of the Canadian Rockies in the past, it may be stated that the climatic conditions prevailing in these mountains, are less favorable, than those prevailing in their extension through the countries south. While admitting that the climate, to some extent, hinders exploration and production, undue weight should not be given to this factor, for placer mining operations, which are more seriously affected by cold than lode mining, being outdoor work, is carried on successfully in the Klondyke, which is practically under the Arctic Circle.

Since the discovery of placer gold in the Klondyke region at Dawson City in 1896, the total coining value of the gold produced by that camp, including 1901, has been $76,500,000 or 46 p. c. of the value of the total production of the Canadian Rockies to date.

That the discovery of other mining camps in these mountains, equally as productive as the Klondyke, waits only on the chance efforts of individual prospectors, or the systematic exploration of organized companies, cannot be denied, and no one can place a limit on the number of "Cripple Creeks," or "Klondykes" or "Rands" that lie hidden away in the recesses of the 1600 miles of Rocky Mountains now practically unexplored in Canadian territory. A comprehensive, systematic exploration extending over years, can only fully answer this.

A mining camp may be considered a geological accident, occuring no man knowing why, or wherefore, here and there, throughout the Rocky Mountains, and generally occupying an area of not more than a few miles in extent, while, perhaps a hundred miles or more of barren country may intervene, before another paying deposit of mineral occurs. The discovery of these mineralized areas, always limited in extent, and hidden away in the mountain fastnesses, at considerable distances apart, and usually covered by debris or vegetation, and in addition, during the winter months, by snow, is no easy matter. The desultory effects of individual prospectors, without training or experience, may fail indefinitely to locate these treasure vaults. The problem should be attacked systematically by a well organized corps of prospectors, operating under the direction of trained geologists. Prospecting in this way could be done only by large private corporations, properly financed, or by the Dominion Government, in the manner to be outlined below.

The inefficiency of the desultory efforts of a few prospectors working on their own account to discover the mineral deposits hidden away in so vast a field will be apparent, when it is borne in mind that these mountains, averaging 1600 miles in length, by at least 500 miles in breadth, cover an area of more than 800,000 square miles—eight times the total area of England, Ireland and Scotland (see comparative areas shown on map 2).

Any plan for prospecting for the mineral deposits in this range of moutains, in order to be effective and reasonably successful, should be conducted under the auspices of the Dominion Government, or, of strong private corporations. Whether by the Government, or by private corporations, the general plan of the campaign should be similar, except as to its scope, which in case of government control should be more extensive than if conducted by private corporations.

Every corporation undertaking to put a prospecting party in the field, should be adequately financed, to carry on the campaign extending over at least 5 years, employing during the prospecting season—6 months—of each year a large force of prospectors. Such a force should be under the general supervision and direction of a field manager, who should be the Geologist-in-Chief of the party. The working force should consist of say 60 men and be divided into sub-divisions or posts of 6 men each, and these should be encamped in suitable locations in the mountains at say 6 or 10 miles distant from each other, moving camp from time to time as the possibilities of the discovery of paying deposits of mineral in one location became exhausted.

Each post should consist of 3 prospectors, 1 assayer, 1 cook, and 1 geologist, or practical miner. The latter should be superintendent of the post and have immediate charge and direction of the explorations, subject to the general control and instructions of the Field Manager. The duty of the entire force of a post, except the cook, would be to thoroughly explore the mountain areas surrounding their camp. All the rock deposits occurring in these areas, suspected of containing the precious or valuable metals, should be analysed on the spot, with blow-pipe, by the assayer. When greater accuracy would be required, the rock would be tested at the assay plants of the party, of which there should be a least two, to be carried along as the party proceeded, at equal distance apart, or at convenient positions, so as to afford the greatest accessibility from either end of the line. The assayer of each post, besides his technical duty, should occupy the position of Assistant Superintendent, and besides doing a share of the regular field work, should help to make the sketch maps, reports, and should keep the records and accounts of the work accomplished by his post. The responsibility for the proper execution of such work would, however, rest with the superintendent. The cook, besides the work of cooking, should act as general roustabout of the post, keeping watch over the pack animals, of which, there should be three at each post.

When deposits of pay mineral were discovered by any post, all the land on which such discoveries were made, would be located for the benefit of the corporation, with such interests reserved for the members of the force as should be agreed upon at the outset. Distributed and operating in this way, the advance of the party would cover a line 90 miles in length, and large areas of the Rocky Mountains would be thoroughly prospected during the life of the campaign and the

reports of the officers covering the result of the work, with maps of the portions of the country explored, would be the exclusive property of the corporation. It is scarcely possible that a campaign of this kind would fail to discover one or more areas of paying mineral.

The discovery of one such area during the life of the campaign would pay the corporation probably one thousand fold on its oulay in the enterprise. As an illustration of the industrial potentialities and creative power of a mining camp, a brief description, or history, of the industrial results of Cripple Creek District will serve.

That district is less than 6 miles square and has been the theatre of fortune makers on whose stage poor men have developed into multimillionaires, in which several towns have arisen as if by magic, have been burned to the ground and rebuilt on smoking embers to modern cities of steel, stone and brick. Its hills are gridironed with steel rails, and dotted with the shaft-houses of 100 mines in which men work night and day in the production of gold. This camp discovered in 1891, had a total recorded production at the end of 1902, amounting to $143,458,100, with the last annual production up to $25,000,000.

Notwithstanding the present activity and prominence of this district, it is interesting to remember that the mineral indications on its surface had been passed over unheeded by prospectors for years. This is another instance which shows that the unorganized efforts of prospectors failed for years to recognize surface indications of one of the greatest mining camps of the world, a fact which could hardly occur under the more thorough methods of a prospecting campaign as outlined above.

PRIVATE CAPITAL NOT LIKELY TO UNDERTAKE THE WORK IN THE MANNER SUGGESTED.

A corporation undertaking a 5 year prospecting campaign, as proposed, would require an available capital to be paid up within that time of $150,000 to $200,000. It would be difficult to assemble this amount of money by subscription from men who are absorbed in their own ordinary business pursuits, and who have given no study to the possibilities of mining enterprises, except to the extent of "Taking a

Flyer" in some stock speculation. Moreover, all the capital of business men is generally required to meet expansion in their own special lines of business, and, there would be little or none available to go into an enterprise of this kind.

In the Dominion of Canada, the per capita circulation of all classes of money, is estimated to be about $15. This amount is totally inadequate to properly sustain the necessary current business of its people, for which there should be, at least, a money circulation of $40 per capita. But not having much over one-third of this amount, the consequence is that the home accumulation of idle capital, that can be safely withdrawn from the ordinary commercial pursuits, is not sufficiently abundant to finance such industrial enterprises, as are required to develop the country's natural resources. As a result, a large portion of the Canadian youth emigrate to find employment for their brain and muscle, while on account of the lack of home capital, even the choicest natural resources of a country remain undeveloped, or fall as plums to foreign capital. As it is a part of the object of this paper to indicate how the money metals held by Canada, as the basis for its Monetary system could be increased, thereby incidentally increasing the per capita circulation which would ultimately result in accumulations of home capital that would be available for the development of the country's natural resources, that subject will now be briefly discussed. The increase of the money metals in the country might be brought about in two ways:

1. By selling to foreign countries merchandise of greater value than would be purchased from them, thereby securing what is known as a favorable balance of trade.

2. By mining and retaining in the country as coin or bullion, the money metals existing in its territory.

The former method involves the complex intricacies of internal and international commerce, and has only a subsidiary bearing on the purpose of this paper which is, in the main, to point out the possibilities of the National Mining Field—The Canadian Rockies—and the best method of developing its resources.

HISTORY OF RECENT DEVELOPMENT IN THE CANADIAN ROCKIES.

In the early '90's, the province of British Columbia which covers about 800 miles in length of the Rocky Mountains, had a very satisfactory code of mining laws. At about this time, prospectors coming over the border from the mining region to the south, discovered the mineral deposits in the Slocan, Rossland, and other districts along the International boundary. They were shortly afterwards able to sell their finds for remunerative sums. The news spreading over the country induced a large emigration of prospectors, miners and capitalists to come into the mining camps of the province, and the vigorous exploration and development of the region was proceeding.

When everything was thus promising well for the future, one ontoward event after another interposed, and progress was checked. Some of these were circumstances over which the people of the Province had no control. But the most damaging to the mining industry, was the enactment of laws, unfavorable to it by the Legislature of British Columbia. Against the protest of the mine owners, and the business men in mining communities, the Legislature continued to pass laws annually, for several succeeding years, that affected the mining industry, more or less, unfavorably.

Not knowing where the end of such legislation might be, capital seeking mining investments, called its agents away from the Province, and prospectors, not finding purchasers for their discoveries left also, so that, at the present time, it is doubtful if there are more than 200 *bona fide* prospectors at work in the vast area of the 400,000 square miles of the Rocky Mountain Cordillera that lie within the Province. For this reason, few, if any, discoveries are being developed, mining operations being confined to the development or extraction of ore, from the mining properties that were purchased some years ago.

These effects, due mainly to bad Provincial legislation, were first felt in the towns and mining camps, then at the more distant business centres, and finally at the coast cities. The general falling off in business, which has taken place all over the Province, appears in strong contrast with the general prosperity existing in the other Provinces of the Dominion, or in the mining states of Mexico, or, in the American mining states just across the International border.

In these states the Rocky Mountains are swarming with prospectors, new mineral areas are being discovered, capital is flowing in, the metal output is increasing, and prosperity abounds.

It is believed, or hoped at least, that the conditions which have thus far contributed to injure the prosperity of the Province, will be corrected so far as possible, at an early day, for the people are now thoroughly awakened to the exceptional condition of their Province, and are demanding such legislation as will encourage and protect capital seeking mining investment. Therefore the repeal of the obnoxious laws now existing on the Statute Books, and the substitution therefor of a new code of mining laws that will be favorable, or at least, fair to the mining industry, may be confidently expected.

But the agents of capital have left the country, and so have the prospectors. These people are profitably engaged elsewhere and now the great question to be solved, is, how to get them to return? Confidence must be restored in some unusual way to be effective within a reasonably short time.

INDIVIDUAL PROSPECTING INEFFECTIVE.

The situation demands that immediate steps be taken along lines already suggested and to be further referred to later in this paper, to carry on the work of prospecting, under the direction of strong comprehensive organizations, on private account, or, by the Dominion Government. A strong movement of this kind, would do more than anything else to induce the tide of emigration to flow towards these regions once more.

Everybody, including the prospectors themselves, is aware of the inefficiency of unorganized prospecting.

Year after year, individual prospectors go for a few months, each season, into the mountains to search for the indications of mineral deposits. Having no records of past efforts of this kind to guide them they may spend the entire season going over the same ground that had been fruitlessly examined, perhaps for each of the several previous seasons, by other prospectors. In the same way, the same ground may absorb the efforts of other prospectors in succeeding seasons. This waste of effort will continue until the exploration of the Canadian Rockies is undertaken in a more intelligent way.

While no one knows how many " Rands " " Cripple Creeks " or " Homestakes " lie hidden away in these mountains, yet no one can fail to see how, under existing conditions and by existing methods, such deposits might remain undiscovered indefinitely, unless the work of exploration is taken up systematically by private corporations, or the Government.

GOVERNMENTAL EXPLORATION NECESSARY.

Systematic exploration could be most effectively carried on by the Dominion Government, the concessions for the temporary occupation of the territory of British Columbia, if any were technically necessary, could be readily secured from that Province. Under the auspices of the Dominion Government, a prospecting party, 5 times as large as the one outlined for private corporations, should be placed in the regions for a campaign of exploration extending over a period of 5 years. The result could hardly fail to be successful. 300 men exploring a region with military precision, under the direction of the best executive talent, advised by the best geologists, would certainly result in finding some of the hidden wealth in these regions. If exploration were undertaken in this way, immigration and capital would follow quickly into these fields.

Once a government prospecting party was in the field, there would be hundreds, if not thousands, of camp followers. Discoveries would be rapidly made, and developed, and the metal output would soon come up to that of the American or Mexican Rockies.

Canada would then have the opportunity of accumulating a large stock of precious metals, which, as bullion, or coined, would warrant the increase of its *per capita* money circulation to a sum equal to that of the United States. Accumulations of home capital would follow which would be available for investment in enterprises organized for the development of the natural resources of the country.

WAYS-AND MEANS.

If the exploration of the Canadian Rockies were undertaken by the Government, the first thing to be considered, would be the methods of finance and provision of means for the proper supervision and administration of the undertaking. These details might, doubtless, be accomplished in a number of ways, but the following seems to the writer to be most expedient and effective.

1. The creation of a Department of Mines and Mining, the head of which would be a member of the Cabinet.

2. To finance this department, the Dominion Government would make a Note Issue of $5,000,000, and place this sum at the disposal of the Minister of Mines.

3. The Minister of Mines would purchase bar silver in the open market from time to time, as it could be coined at the Government Mint hereinafter provided for.

4. The 10,000,000 ozs. of silver that could, presumably, be purchased with the $5,000,000 Note Issue, would coin into at least $10,000,000 of standard half dollars or subsidiary coin.

5. The $10,000,000 thus created, would constitute the funds available for the Minister of Mines to carry on the work of this department, which would include :

6. The erection of a Government Mint Building at the National Capital for the coinage of the nation's metallic money.

The erection and suitable equipment of a building at the same place to be known as the Department of Mines and Geological Survey Building.

8. The appointment of a Department Board, or Mining Commission, of say three persons who should act as assistant secretaries to the Minister of the Mines. The duties of this Board or Commission, their official capacity, as aides, assistants and advisers of the Minister of this department would be to study the requirements of the mining industry in matters of National and Provincial Legislation, transportation, reduction and refining works, labor troubles, etc. and advise wherein, in their judgment, the Industry could be benefitted by change or modification of existing conditions.

GOVERNMENT PLAN.

Organized in this way the Dominion Government would be thoroughly equipped to carry on, systematically and effectively, a comprehensive plan of exploration of the Rocky Mountain regions within its domain.

The plan, while following the same general lines as that proposed for private corporations, would, in some particulars, be essentially different, inasmuch as the exploration carried on by the Government, would be for the benefit of the whole people, and not for the discovery of mines to be worked for private gain.

When a discovery would be made, it should be publicly announced through the proper channels, so that the general public wonld have equal opportunity of locating claims on the public domain in the neighborhood of the discovery.

For a prospecting campaign of this kind, it would be easy for the Government to recruit abundance of volunteers from among the people of every province. As remuneration, all that would be required would be transportation expenses, board, and a small salary, with the privilege granted to each of the party of locating, say two claims, on the choice of the discoveries made each season. The fault would lie with the man himself if this opportunity to him as member of the Government Exploration Party failed to make him a fortune. Excepting the claims to be thus located by the members of the Government party no other private appropriations should be made from the Government discoveries.

They would be for the benefit of the public, or such portion of it as would interest itself in the acquisition and development of the mineral resources.

It is probable that the plan outlined for the creation of a Department of Mines and Mining in the Government and the method suggested for financing it, would meet with some opposition. This is to be expected. Any departure from the dusty precedents of the past, innovations, or progressive measures of any kind, are always thus assailed. However, it is believed that ahyone who takes the time and patience to fairly consider the conditions and opportunities presented, will come to the conclusion that the method proposed would hurt no one, and benefit all. The results would be of great national importance, as the undertaking of the enterprise by the Government would be almost certain to inaugurate an era of permanent national prosperity.

The note issue of $5,000,000 would be a very small strain on the credit of the Government—it amounts only to the cost of one armored cruiser.

The 10,000,000 ozs. of silver, which this issue would purchase, when coined into $10,000,000, of subsidiary coin, would add only $2.00 to the per capita money circulation of the Dominion, and, with the note issue would bring it up to $18.00, which would still be less than half what it should be.

The funds, thus placed at the credit of the newly created department, would be sufficient to finance all its operations for the five years campaign. During this time these funds would work their way into the general circulation of the Dominion, through the payments made for the labor and supplies used in the construction and equipment of the buildings proposed for the offices of the department, the salaries of the regular and special staffs, the expenses of outfitting and equipping, and the labor of the prospecting corps.

CONCLUSION.

The writer has endeavored, in what has already been said, to show his belief in the mining possibilities of the Canadian Rockies and has stated the reasons for the faith that is in him.

The method suggested for their exploration is the one that, to him, seems most feasible, and certain of success, and was formulated after study, for a number of years past, of different ways that might be adopted for that purpose. The method proposed may seem visionary and impracticable to some, at first sight, and while admitting that all the details of the plan for financing the undertaking are not warranted by established custom or precedent, nevertheless, there does not appear to be any good reason why it could not be adopted, as it would in no way injure the national credit.

It may be alleged that the importance of the advantages that would be gained, by carrying out the undertaking, have dwarfed all the obstacles that interpose, and, that the conclusions arrived at, were reached because the ends justified the means. If there can be any better way devised, than that proposed, the writer would be only too glad to have that adopted instead. But some vigorous steps should be taken for this purpose by the Dominion Government, for, the success of the mining industry, affects not merely the camp, district, or province in which the mines are located, but all parts of the country, and stands highest among all the factors in the upbuilding of the nation's prosperity. The establishment of a Department of Mines and Mining, by the Dominion Government, would be a proper recognition of the importance of this industry, which is as yet in its infancy, and it would have an inspiring practical effect in attracting emigration for the development of the resources that now lie dormant and useless.

In no department of industry can Government aid and supervision be of such direct and immediate benefit. By systematic exploration of the Rocky Mountains, many areas of payable mineral will be discovered, that would otherwise, long remain unknown. The reports of the progress and results that would be accomplished by the proposed Government exploration party would direct the efforts of thousands of prospectors and save a vast amount of labor and expenditure now devoted to useless ends and leading only to disappointment, thereby creating an erroneous impression of the mineral possibilities of this field.

The desire to increase the production of the precious metals should not be considered as a narrow, local, or selfish one. The beneficient effect of a large production of the precious metals reaches beyond the interest of the miner who mines it, the railroad that transports it, or the locality in which it is found. The success of the mining industry stimulates every other industry, aids commerce and civilization and brings general prosperity. As such, it is entitled to Government recognition and aid, for, to encourage and protect the natural productive industries of a nation must be considered the highest type of statesmanship, under any form of Government.

That the Canadian Rockies, with an area equal to either the American or Mexican Rockies, and with geological conditions as favorable for mineral deposits, should be allowed to remain so far behind these countries in the production of the precious metals, is not creditable to the people of the Dominion.

As an excuse for any discrepancies that may be found to exist in the figures or statistics used by the writer, it should be understood that the paper was written at odd times, and mostly at places where no books of reference were available.

The figures and statistics used were taken from notes recorded over a considerable period, aud from various sources, but should be approximately correct for all practical purposes.

If this paper attracts the attention that the mining possibilities of the Canadian Rockies deserves and leads to the adoption.of some comprehensive plan for their systematic exploration, it will have served the object of the writer.

The Influence of Government upon Mining.

By Mr. Edmund B. Kirby, E.M., Rossland, B.C.

In most mining districts of the world the difficulties which we as engineers, have to confront are mainly business-technical problems. Methods and economies in mining, transportation, milling and smelting, studied both from the scientific and business side, absorb our attention. In few cases do questions of State economies force themselves upon us, because mining is almost everywhere a favored industry treated by governments with fostering care, and considered worthy of every sacrifice and every encouragement by the State. It is rightly recognized as the mother of industries, focusing the attention of the entire world upon each newly-discovered mineral area. Upon this all the resources of civilization in men, money, and skill are poured out. Around it agriculture, stock-raising and lumbering spring up, railroads appear without the aid of land grants or subsidies, manufactures and towns follow, and a common wealth is established.

Now the British Columbia mining industry is unique in the world, not only in its entire lack of State recognition and fostering, but in the fact that difficulties imposed by State economics overshadow in importance all the ordinary technical and business problems with which mining men have to deal. It affords to-day a curious and interesting illustration of the injury wrought by unwise government, and also of the reaction of repressed mining on commerce and other industries. These effects are emphasized by contrast with the present prosperous condition of the other Provinces of the Dominion and also of the United States.

It is clearly recognized by the Canadian Mining Institute that British Columbia contains one of the largest and most promising mineral areas of the Dominion. But in considering the welfare of its leading industry of what use is it to concentrate attention on the fine

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[Since this paper was presented in September, 1902, the Provincial Government has given an assurance that the two per cent. tax will be removed.—Secretary.]

points of machinery, mining methods and ore treatment if we ignore such realities as a Government taxation which amounts to one-fifth of the gross value of its products? And a single item of which bars the treatment of low grade ores.

The phenomenon before us presents the following features: The Rocky Mountain range has been developed from lower South America to British Columbia, yielding a practically continuous chain of productive mining districts. It is found equally productive at the two points touched of Southern British Columbia and the Yukon. The unexplored area between, some six hundred miles of which is in British British Columbia, should average up as well as that already known. Concerning the development of this area I quote from a memorial of the British Columbia Mining Association, of June 28, 1901:—

> "The development of these resources, begun a few years ago "so auspiciously, has been brought to a practical standstill, and "whereas a few years ago the mountains were swarming with "prospectors, to-day these pioneers of the mining industry have "practically disappeared. The flow of capital into the Province "has been practically cut off, the metal production is at present "decreasing, numbers of producing mines have closed down and "those operating have with few exceptions ceased to pay "dividends. The working mines are struggling under heavy "burdens which are still accumulating each year. It is now "frankly admitted by mining men that the industry is prostrated "in many mining divisions, and that its conditlon is rapidly "becoming worse."

Allowing for all the reaction from the mining boom, the association correctly ascribes the increasing paralysis to two main causes—excessive taxation and oppressive legislation.

At present, conditions are even worse than those described. Prospecting, and the development of new deposits to replace those exhausted, have practically ceased. Of 14,326 Crown-granted and recorded claims held December 31, 1901, only 78 yielded ore in excess of 100 tons total production for the year. This is about one claim in every 2,000 held. The bulk of the tonnage was confined to a dozen or so mines, most of these operating at a loss. The increased metal statistics for 1901, $15,000,000 against $11,348,000 for 1900, was due entirely to two mines, neither or which yielded dividends, and one of which has announced a large increase in its debt. Moreover, the statistical figures of production are fictitious in that the metals are valued theoretically by New Vork quotations for the refined product, the true, or actual values, received by British Columbia industry being much less. Meanwhile the serious financial condition of the province has been clearly shown by Mr F. J. Proctor in his pamphlet on "The Financial Crisis in British Columbia," and it is currently reported that the Government met with failure in its recent attempt to float another loan in London. The stagnation of commerce and the present exodus of population is recognized by every one.

It is not of interest here to go into details about the oppressive and threatening legislation which, in British Columbia, has so characterized the dealings of the State with its chief industry. What is of interest is the spectacle, unknown elsewhere in the Dominion, or in the Empire, and probably unparalleled in the world, of a mining district trying to exist under a burden of taxation which amounts to between 20 and 30 p.c. of its gross product.

The gross products of British Columbia in 1901, from its five principal, or basic industries, were about $27,000,000, distributed as follows:

Industry	Probable Annual Production.	Per Cent.
Metal mining	$15,070,382	55.1
Coal mining	5,016,398	18.3
Fisheries	3,065,900	11.2
Lumbering	1,690,000	6.2
Agriculture and Stockraising	2,520,000	9.2
	$27,362,680	100.7

Without considering an increase of about $800,000 yearly in the $10,000,000 debt, the actual taxes collected, Dominion and Provincial, amount to $5,350,000 which is 20 p.c. of everything produced from these industries. This is from a population which probably does not exceed 125,000 or 130,000 whites. Through the shifting of taxation by the other industries on mining the burden on the latter probably approaches 30 p.c. of its product, even when the latter is valued by the aforesaid fictitious method. In this remarkable state of affairs the fact that mining exists at all is the strongest evidence of the value of British Columbia's mineral deposits, and of the future which awaits the industry here when these artificial burdens are removed.

Even if the total load permitted it, low grade ore must remain for the most part untouched on account of the so-called 2 p.c. tax on the gross output of mines. This tax is only one item in the total mentioned above, but it has the peculiar effect of exacting an increasing proportion of the profits on the lower grade of ores. For instance, on the milling grades of Rossland it will seize anywhere from ten to twenty per cent. of the net profit. This bars Treadwell's in British Columbia.

The present state of affairs is instructive not only to the mining profession, showing how unwise Goverment can injure mining, but also to students of economics, presenting an extreme case of the blighting effects of taxation upon industry. To the student the phenomenon is marked by the same familiar symptoms which always accompany evils caused by acts of the political organism. There is the same curious indifference and refusal to see facts as they are, the same tendency to ascribe the evils to every cause but the right one. There is the usual effort to conceal the truth from the outside world and to condemn those who boldly and clearly call for reform. There is the same old anxiety not to correct the evil but to find excuses for evading action.

WHAT GOVERNMENT COULD DO FOR MINING.

Buckle, in his History of Civilization, briefly characterizes its progress as the abolition of bad laws. Beyond this, industry requires nothing. All it wants from the state is what Diogenes asked from Alexander, "Keep out of my sunlight." As every economist knows the State is all powerful to injure industry but cannot directly aid it except by the familiar procedure of assisting one branch by robbing others for its.

benefit, Indirectly, however, the State can do wonders by the gradual, persistent removal of laws which oppress. Few people realize the sensitiveness of industry, or the narrow margin of profit by which it lives. Upon its delicate organization taxation is literally the hand of death. It shrinks, withers or dies at its touch. Taxation which is excessive or badly placed is worse in effect than war or pestilence. As industry declines revenues decrease, it becomes harder to reduce taxes, the burden on survivors increases, and thus the disease accelerates its own progress. Such taxation kills the goose that lays the golden eggs, and the bankruptcy of the State inevitably follows.

The simple principles of modern scientific taxation are well understood. In theory, if not in practice, the world has advanced since Colbert, the Famous Minister of France, summarized government finance simply as "the art of plucking the goose with the least amount of squealing." In the light of modern knowledge taxes may be so laid that industry is not only uninjured, but is on the contrary actually benefitted by them. In this 20th century there is no excuse for excessive taxation or mediæval methods.

The State, if it will, may not only relieve the "mother of industries" from all its burdens, but may in a less important way encourage and aid it by attending to those matters which are beyond private enterprise. Maps, geological surveys, studies of districts, and the collection and distribution of all kinds of information valuable to the industry, are peculiarly the province of the State. It should, however, be restricted to this field, the only exceptions being the few cases where it is necessary for the State to interfere by regulations for the distribution of mining property and for the public safety. It is easy for a Department of Mines to maintain such close touch and cordial relations with the whole industry as to secure its effective co-operation in all its work. It should in fact, as well as in theory, be its representative, its advocate and its watchful guardian.

As to the outlook for relief in British Columbia, we do not delude ourselves with any illusions. The disease has gone too far. History shows clearly that in all such cases the evil forces which control the machinery of government hold out against reform. No government ever reforms until it is forced to do so by the overwhelming power of popular will. The exertion of this power is always long delayed because of the apathy and blindness of the public towards economic questions and the long time required for it to recognize the causes of its distress. It is probable that a long period of depression and suffering will be necessary to educate voters and compel reform. Meanwhile only the richest and most fortunate enterprises will survive.

Notwithstanding the gloom of to-day we mining men, looking far beyond the present, have a clear view of the future grandeur of the common-wealth of British Columbia. We know its wonderful natural resources, the character and energy of its people. We know that civilization cannot be held back. Some day there will be good government, and with this one requisite supplied will appear an era of prosperity beyond the wildest hopes. Whether its arrival will find us here or laboring in other parts of the world we neither know nor care. We only know our present duty, which is to maintain a united front to the evils before us and to steadily press the fight to reform.

The detailed figures referred to are as follows:—

POPULATION OF BRITISH COLUMBIA.

The census of 1901 is not yet published. The estimate of the Provincial Government (see argument of Hon. James Dunsmuir in Report of Delegation to Ottawa) is 150,000, including 23,000 Indians and 15,000 Japanese and Chinese, and 112,000 whites. This is undoubtedly low and will probably be found near to 125,000 to 130,000 whites.

REVENUES CONTRIBUTED TO GOVERNMENT BY THIS POPULATION.

These are Dominion, Provincial and Municipal revenues.

Dominion Revenues.—From the "Report submitted to the Lieutenant-Governor by Hon. James Dunsmuir, Premier, and Hon. D. M. Eberts, Attorney-General, on their mission to Ottawa as a delegation from the Government of British Columbia," March 15th, 1901. This, at much length, calls the attention of the Dominion Government to the fact that the revenue contributed by British Columbia to the Dominion is excessive, and out of proportion to that furnished by other Provinces, and estimates its amount for 1901 at $3,750,000 from the aforesaid population.

Provincial Expenditure and Revenue :—

Expenditures (from "Estimates of Revenue and Expenditure for year ending June 30, 1902") page 2		$2,475,335 00
Supplementary Estimate No. 1 (see separate sheet)		50,140 00
Supplementary Estimate No. 2 (see Estimates for year ending June 30, 1903) page 31		192,408 00
Total		$2,718,183 00
Revenues (from "Estimates of Revenue and Expenditure for year ending June 30th, 1902"), page 1		$2,140,751 00
Less Receipts from Dominion Government and land sales		539,151 00
Revenue to be contributed by Province		$1,601,600 00
Expected Expenditures	$2,718,183 00	
Expected Revenues	2 140,751 00	
Expected Deficiency to increase debt	$577,432 00	

This revenue contributed to the Dominion and Provincial Governments is far from being the entire amount taken out of this population for Governmental purposes. It is, however, the only portion for which figures are yet published. To it must be added local or municipal revenues amounting to a large but unknown aggregate, and the increased cost of supplies purchased in the Eastern Provinces due to the unnaturally high prices fixed by the tariff. While this is not a part of Government revenue, it is the accompanying result of the tariff tax and the same to the payer, British Columbia, as is shown by the Provincial Government in its argument to the Dominion Government,—*Report of the Delegation to Ottawa, March 15th, 1901.* The additional cash which it takes out of the population can only be guessed at, but it is evidently a large sum.

SUMMARY.

Dominion Revenue....	$3.750,000 00
Provincial Revenue............	1.601,600 00
	$5.351,600 00
Local and Municipal Revenue.....	? ? ?
Tariff increase on Eastern supplies	? ? ?
Total cash taken out of population by Govt..	? ? ?

INDEBTEDNESS.

From the British Columbia Public Accounts for the year ending June 30, 1901, page 7, the Provincial debt funded and floating on that date is $9,619,482. The Public Accounts for the year ending June 30th, 1902, are not yet published, but as the increase between 1900 and June 30th, 1901, was $952,424, the total on June 30th, 1902, evidently exceeds $10,000,000.

PRODUCTION OF THE FIVE PRINCIPAL INDUSTRIES FOR 1901.

The first two are accurate. The others for want of statistics, are approximate.

The Report of the Minister of Mines for year ending December 31, 1901, gives:—

Metal Mining...........	$15,070,382
Coal Mining	5,016,398

For the other three the only statistics so far published are those given in the 22nd Annual Report of the British Columbia Board of Trade, 1901:—

Fisheries.—Exports of Fisheries for 1901, page 65.	$2,665.915
From the proportion of total production to exports given for the salmon catch of 1900, page 57, the amount to be added for home consumption is roughly estimated as...............	400,000
Total product of Fisheries.....	$3,065,900

Lumbering.—From the same report, page 23:—

The total timber cut on Crown lands, leaseholds, private property, is 223,374,723 feet, which at $7.50 is	$1,690,000

Agriculture and Stockraising.—From the same report, page 65, the exports of produce are as follows:—

Animals and their produce	$170,218
Agricultural products	231,544
Miscellaneous	1,317,687
	$1,719,449
To which is added 50 per cent. to cover the value of the product of this industry consumed locally	800,000
Probable production	$2,520,000

EXPLANATORY REMARKS.

These statistics merely bring to a later date those of the British Columbia Mining Association in their Memorial to the Governor-General-in-Council, June 28th, 1901. The figures of the taxation load speak for themselves, but following their method of presentation a comparison is made between the revenue taken for government and the production of the five principal or basic industries. Since the only object is to illustrate its size, it may of course be compared with anything desired. The five basic industries are selected as the most interesting and useful basis. It is of course impossible to compare with the total production of economic wealth by all occupations, because this is unknown, and if known would be less useful.

These basic occupations support practically all the others. So that the population may be roughly divided into five portions, each of which includes those dependent directly or indirectly upon one of these basic occupations, and therefore conveniently classed as a part of that industry. The mining industry, for instance, is taken to mean that portion of the population with all its minor occupations which would disappear if all the mines suddently vanished. The comparison made is between the Government revenues extracted from that portion and the mine production which sustains it.

[NOTE BY SECRETARY.—The 1901 Census figures, since published, are as follows:—

Whites	132,483
Indians	25,593
Chinese	14,689
Japanese	4 507
Total population	177,272

DISCUSSION.

Mr. **BERNARD MACDONALD** referred to the light taxation on the gold mining industry in Alaska, which he contrasted with the conditions under which the mines were operated in British Columbia. In this province the average wages are as high or higher than in the American mining camps, while the hours of labor are shorter, owing to the eight hour law recently passed by the province. The prices paid for mining machinery and supplies are equal to those paid in the American mining camps, plus the Dominion duty on importation, which amounts to nearly 25 per cent. *ad valorem*. Add to these handicaps the provincial tax of two per cent. levied on gross values of the ore mined after the cost of freight and treatment is deducted, and other unfavorable legislation passed in recent parliaments, the sum total of which constitutes a burden under which no industry can prosper.

Mr. **B. T. A. BELL**.—Mr. Kirby's remarks have opened a wide field for discussion. I am not, however, quite certain that the Provincial Tax upon your output is entirely responsible for the depressed state of mining in British Columbia. There has naturally been a reaction from the 'boom,' and wild-cat speculation, incompetent management, over capitalization, depressed markets, and other causes, have played their part in contributing to the present temporary stagnation in mining activity. A tax upon industry is always to be deplored, and while at first sight this Provincial Government imposition of two per cent. may appear insignificant in itself, it unquestionably is an onerous burden on an industry whose future success and prosperity must depend upon the extraction of its low grade ores. A similar tax was, many years ago, proposed in Quebec, but, happily, was abandoned. In Ontario foolish politicians have been openly advocating an export tax upon the copper, nickel and other ores mined in that province, but I am glad to say wiser counsels have prevailed, and it is not likely any such legislation will ever go into effect. I am sure we are all very much indebted to Mr. Kirby for having furnished us with such a brimful topic for discussion at this meeting of the Institute.

Mr. WM. THOMPSON.—I think we are specially indebted to Mr. Kirby for having spent a good day's work at the last moment in the production of this paper, and I am sure his trenchant criticism of the treatment our industry receives from the Government cannot fail to be of the greatest possible benefit to the mining industry of British Columbia. We recently had the pleasure of entertaining the Hon. Mr. Prior, the Minister of Mines. We took him under our wing and did not do "a thing to him." (Laughter.) But as soon as he left our genial company and the Scotch began to work off (Laughter) he changed his tune and he now appears to be not quite so sure that the mining industry was dead. We should have regaled him with a red herring (laughter) for he evidently has gone from us with the idea that we really had some money after all and that the government should have some more of it. (Laughter.) It is all very well for the Slocan mine managers to get together, and for us in Rossland and in Nelson to sympathise with them, but unless the public is made acquainted with the real facts, unless the people are made to realize the part which foolish legislation has played in bringing about this deplorable state of affairs, unless we act vigorously and in no uncertain manner in behalf of our own interests and the interests of our shareholders, I am afraid very little good will come out of it. As Mr. MacDonald and Mr. Kirby have well pointed out, the mining industries of the Province are severely handicapped by taxation and duties, and there is an immense tonnage of ore on the dumps and in the mines which under better treatment and more liberal legislation would be mined at a profit, but which must lie there untouched until conditions change. (Applause.) This state of affairs cannot go on. Hardly a session of the Legislature passes without some tinkering with our mining legislation—some new effort to hamper and restrict mining. Last session we had several examples. Just as soon as the Government is satisfied we are making progress, down comes the axe, and tomorrow the hours of labour may be still further reduced and the mineral tax increased. We asked Mr. Prior to give us a fair fighting chance, Our members at Victoria ought to know, and be made to realize, the injury foolish mining legislation has inflicted upon the mining industry of the Province, and an effort must also be made at Ottawa to secure relief from burdensome duties, especially upon our machinery and mining supplies. If this thing continues nothing else will remain but to shut down every mine and let them have them to themselves. (Applause.)

Mr. A. SHARP.—Allow me to say how I appreciate the observations of Mr. Kirby and how much they have been needed, not only at a meeting of the Institute, but throughout the Province of British Columbia. I have lived in this Province for a great many years. I have tried in my own little way to affect the legislation of the Province just upon the lines which Mr. Kirby has laid before us tonight. There is no doubt whatever that the mining industry, as an industry, has been crippled in the way he pointed out to us. At the same time, I cannot help saying that the mining engineers, the mine superintendents, and the owners of the mines, have hitherto been very much to blame. They have held aloof and been indifferent when they should have been active. I have appeared on the political platform at several elections and endeavored to show the harmful effects of much of our provincial legislation. I have done so almost alone without a single mining associate. I believe, that if mine owners, mining engineers and mine superintendents would use their great influence to counteract what is known as the popular cry in the Province we would be able to send members to the Legislature whose views would be more in accordance with our demands. I hope the Institute will go into this and aid us to prevent further legislation being enacted which will handicap mining as it is, and has been in the past.

Mr. H. E. CROASDAILE said that there were statements contained in this paper of a very grave nature. He did not question the accuracy of Mr. Kirby's figures, but he thought the exact data from which they were derived should be given. The bald statement that the mining industry of the province had to pay 20 to 30 per cent. of its total product in taxation would assuredly have the effect of restraining capital from coming into the country. It should be shown in detail just how that estimate is arrived at. Another statement made by Mr. Kirby was that the 2 per cent. tax absolutely bars the treatment of low-grade ores. This was a most far reaching assertion and should be backed by proof of the clearest nature. Statements of this kind contained in the paper under discussion, if permitted to go broadcast without substantial evidence of their accuracy, would work incalculable injury to the mining industry. Upon the estimates of Mr. Kirby the mining industry of the province had to bear over $4,000,000 of the annual taxation, and this upon a production of $15,000,000. He was not prepared to accept these estimates as a fair presentation of the facts, and he thought Mr. Kirby owed it to the meeting to show clearly his grounds for making such statements.

Mr. EDMUND B. KIRBY.—I should be only to pleased to give the most full explanation of my authorities for these figures. As you may readily imagine, I would not have ventured to present such appalling facts until they were verified from the most authentic sources. They are intended as a reproduction of those presented a year ago in the Memorial of the British Columbia Mining Association, which attracted so much attention and discussion. This has stood fire for a year and no one has been able to call its fignres in question. Every statement made, I am prepared to verify. Some of the data are at my hotel, and the rest in Rossland. If Mr. Croasdaile, or other members, would like to see them and go thoroughly into details I should be pleased to do so with them.

Mr. H. E. CROASDAILE.—I must point out that Mr. Kirby has ignored my question. How is he able to show that because the province pays taxes amounting to $5,400,000, that therefore the mining industry pays in taxation 20 per cent. to 30 per cent. of the total production of mining? The mining section of the population is very small compared with the production, and taxation is usually dependent on population.

Mr. KIRBY.—I did not know I was not answering the question fully, because I desire to do so. Here we are face to face with the hard fact of $5,350,000 cash revenue paid yearly by this small population to the two Governments, without even counting the additional local municipal taxaticn. We cannot get away from that fact. The point that I am trying to make is that this is excessive, out of all reason, and the main cause of our present distress. To realize how big it is, to illustrate it to our minds, we must compare it with something. You may compare it with taxation elsewhere, or with the small population paying it, or with their production out of which it is paid, or with anything else you please. I have, merely to give a clear view of it, compared it with the total production of the five basic industries. It was possible to get approximate statistics for these, and they support the other industries. The $5,350,000 is 20 per cent. of their total of $27,000,000 production. As a matter of fact, the mining industry bears much more than the others because the other four get partial relief by raising prices, they shift part of their share in the higher prices of supplies furnished to mining. Moreover, some of the heaviest tax items bear more upon mining than upon the other industries. We mining men, who pay out the cash, find it no trouble to realize the magnitude of our taxation. For instance, the War Eagle and Centre Star mines which have been operated five and three years respectively have paid in dividends $64,000, and approximately $160,000 in taxes which can be estimated. This amounts to one-fourth of our profits and it does not include much reflected taxation which can be recognized but not figured.

Mr. H. E. CROASDAILE.—I thought that Mr. Kirby had probably gone into the figures thoroughly to apportion the amount paid by mining. It is rather a bold statement to say that mining is loaded up with such an immense tax without the figures to support it. I do not agree with his way of arriving at it by deduction. For instance, Victoria and Vancouver have between them a population of 50,000, and pay a large amount of revenue, although they do not begin to produce the amount that the Kootenay and Boundary countries, with say 15,000 population do. You can hardly load that part of the revenue on the mining industry. If the customs returns were taken and the amounts collected from the 2 per cent. tax, and other actual taxation, I do not believe they would come anywhere near the figure quoted. I must protest that such a statement that the mines are paying a tax of 30 per cent. on their gross output should not be made without the clearest proof that such was the case. It is a very harmful statement.

Mr. KIRBY.—To answer the question as to how the taxation of a mining community is taxation of the mining industry, I would ask: Is it from borrowings by Tom, Dick or Harry? Does it come from the remittance men? It comes out of production. The numerous tax items, direct and indirect, taken from various parts of the community are traceable through many intricate channels back to its basic industry, the mines. They pay it in the increased cost of everything derived from the community.

Mr. BERNARD MACDONALD—I think Mr. Kirby's paper is intended to be simply a statement of fact and the figures warranting it will doubtless be forthcoming in due time. If it would be acceptable to the members of the Institute, it might be well to incorporate with this paper the statements presented in the Memorial of the Mine Owners Association. I think this Memorial gives many figures which go to support the statements in Mr. Kirby's paper.

Mr. H. E. CROASDALE—As Mr. Kirby and Mr. MacDonald were the gentlemen who prepared that very able presentment of the case of the mine owners, it would hardly do to appeal to it for reference to prove their present statements. I want to get at whether Mr. Kirby has gone into the matter more deeply than appears on the face of the report.

Mr. WM. THOMPSON—I must confess that I am surprised that Mr. Croasdaile should stand up and assert that the mineral tax is the only direct tax upon our mines. The Le Roi Mining Co. desired to purchase a large hoisting engine. It could not be obtained in Canada, and had to be purchased in the United States. The company had to pay a duty of something like $6,000 on that single engine. What was that but a direct tax upon the mining industry? If a piece of machinery, which cost $14,000 at Northport, costs laid down at Rossland $20,000, surely that is a very serious disadvantage to the mining industry of British Columbia. We are taxed on our powder, on our candles, on our steel, our oil, in fact on everything we use in our mines. These mountains are rich in mineral wealth, but much of the ores are low grade and unprofitable to work under existing conditions. No mine manager objects to reasonable taxation.

It is the accumulation of a little here and a little there which makes it impossible to carry on mining and make it pay. No wonder that last year several millions were invested in Mexico from various sources but largely from London. Their mines are no better than ours, but the investor is treated more liberally and it is possible to make something for the shareholders. I must certainly object to Mr. Croasdaile's contention that the two per cent. tax is the only burden our mines have to bear.

Mr. H. E. CROASDAILE—If Mr. Kirby's logic is correct, if the mines produce more, then the taxes must go up. If the mines produced $20,000,000, then taxation would go up a million dollars. I don't see it in that light. Every citizen has to bear his share of taxation. It is not fair to say that every tax is on the mines. The only way to consider the situation is to get a direct statement of the taxation of mines, as mines.

Mr. KIRBY—It includes all Dominion and Provincial taxation for which we have exact figures, but, for want of these, omits local or municipal taxes, and also the increased cost of goods from the Eastern Provinces caused by the Tariff tax. We may apportion it among the leading industries, or figure it per capita, or in any other way which will show its size. The comparison is not important. Look at it any way you please. By the mining industry is meant that portion of the population who are dependent directly or indirectly upon the operation of the mines. To find out who they are, close the mines and see who is left. In the mining districts, almost everyone is so dependent. In such communities the taxes are taken, it is true, from different sources, but I repeat where does the money come from. It is very simple. To find out, close the mines and see how much revenue then flows out.

Mr. SMITH CURTIS, M.L.A.—I merely came to this meeting to listen and to learn, but I must say a few words. Whether we agree with Mr. Kirby or not, we should be thankful to him for having brought this important question of the taxation of our mines so clearly and forcibly to the attention of the members of this Institute. Mr. Kirby's statement of the revenue collected from the various industries is correct. I had occasion to verify these figures and I know they are substantially correct. We have heard of the heavy burdens placed upon the various industries of British Columbia, and of these the mining industries of the Province, coal and metalliferous mining, overshadow all others, and we have the right to ask whether these taxes are unnecessarily burdensome. It is our right to know how that revenue is applied, and how much of it is applied for the benefit and to promote the development of mining in the Province, but we have no time to discuss that to-day. But I must say that after allowing for the costs of administration, no fair proportion of the balance is applied for the benefit of the mining interests, and especially is this so of the $3,800,000 British Columbia contributes to the Dominion Treasury. Now, as to who pays the taxes, Mr. Kirby is quite within the mark. If you tracethe source from which each person gets the money to pay these taxes, amounting as they do to 20 p.c. of the total export of the Province, it will be found that by far the greater proportion comes out of the mining industry. In the city of Rossland a merchant pays $3.00 poll tax; he has to get that money: where does he get it? He gets it out of the miner, and the miner gets it out of the mining industry. And so you may go on with every other tax paid and you will find that ultimately in the great majority of cases the tax falls upon the mining industry.

THE SECRETARY—I would suggest that Mr. Kirby's paper, together with the discussion, be printed in pamphlet form and widely circulated. On motion of Mr. S. S. Fowler this was agreed to.

Note on Asbestos Mining in Asiatic Russia.

By H. C. REIHLE, M.E., Black Lake, Ont.

The accompanying photographs of the Corewo and Baron Girar de Soukanton asbestos mines, situated in Asiatic, Russia, may be of interest to members of the Institute, particularly those of them engaged in the production of asbestos. These mines are remarkable for the fact that even with a production of 1500 to 1700 tons of asbestos per season, the mining work is all done without the aid of machinery or explosives. The rock is essentially a serpentine, but is quite decomposed to a depth of about 45 feet, so that it resembles a clayey gravel. The ground carries more asbestos to a given area than our Canadian mines, but the veins are not so heavy nor of so white a colour as our output. Again, our veins generally appear as "twin veins," while the Russian veins are only single veins. Mining operations are all carried on upon very antiquated systems, while proper milling plant, practically does not exist. Experiments in milling are, however, in progress, and are very vivid reminders of what occured at the Quebec mines years ago. The working force at these mines numbers up to 1700 men in the season (*i.e.* each mine) and is recruited from the Russian Mujiks or peasants. The wages paid ordinary labour is about 33 to 38 cents a day, with free sleeping quarters. These mines also suffer from a scarcity of labour during the harvesting time, the same as the Canadian mines do. Adjacent lakes will prevent these mines from ever attaining the depths of our mines owing to the very porous nature of the earth—the lakes being on nearly the same level as the mines.

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Mining in the North-West, 1902.

By Frank B. Smith, C. & M.E., Calgary, Alta.

Mining in the North West Territories may be clearly divided into five districts, where mines are in operation, Canmore and Anthracite, Lethbridge, Souris, Edmonton and Blairmore.

Mining at Canmore is actively carried on all the year round, the output of coal being entirely consumed by the locomotives of the Canadian Pacific Railway. These mines has been in operation for over twelve (12) years, principally by the one company, the H. W. McNeill Co., with head offices at Anthracite, Alta.

No. 3 slope is sunk to a depth of 650 feet with workings mainly to the east over a mile in length. Within the past year a new underground slope has been sunk on No. 3 seam with cross-cut tunnels to No. 1 and 2 seams; the extra lift of coal thus gained will insure a steady output from this mine for a number of years. Development work has also been pushed to the west of the slope, but troubled ground has materially hindered operations. About 2 miles to the east of No. 3 slope prospecting work is being done and the indications, of a fairly large field are very hopeful.

Anthracite, from which mine the hard coal consumers of the west depend entirely for their supply, is at the present time crippled in its output, on account of the negotiations between the operating company and the owners of the adjoining property failing to agree on the point of royalty. The coal area, owned by the present company operating, is practically worked out, but a favorable opportunity presents itself to bring the coal from the adjoining property out of the slope now in use. Should this slope be abandoned the cost of extracting the anthracite coal from the adjoining property, by driving a new tunnel to tap the seams, will be greatly increased to the operator or consumer. Lethbridge Mine which has supplied the wants of the North West Territories since the country first began to be settled, still holds the sway in the domestic coal market. The haulage roads extend for miles, radiating from the shaft in all directions to within 1,000 feet of the working faces. This system of haulage is extended as the working faces advance, and these extensions are in such a direction that the present shaft will be economically available for hoisting for many years to come. The mine, although not tested to its full capacity last year, on account of a lack of cars, was producing in the height of the season over 900 tons per day.

Coal mining in south eastern Assiniboia has greatly benefitted by the coal famine in the Manitoba market, the output for the past year being more than double any former year. There are three mines in operation, Roche Percee, Souris No. 1, and Souris No. 2, the latter producing the greatest tonnage, with development work ahead capable of a production of 600 tons per day.

Edmonton coal mining, like Edmonton real estate, has taken an unprecedented boom, not unprecedented to the inhabitants of that city, but certainly to the ears and eyes of the outside public. The whole surrounding country is underlaid by strata of coal varying from 2 feet to 12 feet in thickness. Altogether there are about thirty independent operators within a radius of twenty miles, each of them producing from three to thirty tons per day. The coal is lignitic in nature, very suitable for domestic purposes, and stationary boilers. The great stir in railway circles is no doubt the cause of all this activity, and as soon as a trans-continental road penetrates the country, these numerous small mines will be closed down and coal mining will be carried on more extensively by two or three companies operating large areas.

Blairmore coal mining district, which has only been known as a coal producer for the past 18 months, has at the present time a larger output and more extended market than any other coal district in the Territories. The principal mine in operation is the Frank mine situated close to the town of Frank Alta. Towards the end of 1900 this mine was opened, and, in less than two years, the output has been increased to 75,000 tons. The peculiar conditions of this seam, (vertical) were conducive to the quick getting of coal, and now that the development work is so far advanced, the capacity of the mines is practically unlimited. The main tunnel has been driven over a mile in length straight into the mountain with rooms worked to the surface for nearly half that distance, over seventy per cent. of the coal still remaining in them. This coal can now be drawn at any time, and the output is only curtailed by the means that the coal can be handled in the mine and at the tipple.

Another mine operated in this district is Gold Creek Colliery owned by the United Gold Fields Co. of British Columbia. A branch railroad seven miles in length has been completed to the mine but few shipments have been made. Many other prospects in this district are being developed and the quality of coal is similar in most cases. The only difficulty that exists in making this part of the country the largest producer in the Dominion is the means of transportation.

Rock Drilling and Blasting.

By NORMAN W. PARLEE, McGill University.*

The process of drilling rock has passed through many important changes during the past few years. The old style of drilling by hand has been superseded by the modern machine drill, and steam as a motive power has been replaced by compressed air. Hand drilling is still in vogue, of course, in ordinary prospecting and minor development work, but as soon as a mine has been developed past the stage of a prospect, power plants are erected and compressed air does the work that was done before by the hammer. In fact, to such an extent has hammer work been done away with, that many miners are machine miners only, and do not profess to drill with hand steel at all.

The advent of the machine drill has marked an important epoch in the history of metal lode mining. By the consequent reduction of mining expenses it has made it possible to take out ore which otherwise could not be profitably worked, and in this way has enlarged the mining industry to a remarkable extent. Indeed, many mining camps to-day owe their existence entirely to the invention and development of these machines.

The replacement of steam by compressed air is also an important advancement. Air is more easily handled than steam, the miner is not so liable to injury from burning, and he is not compelled to work in such an uncomfortable atmosphere. The timber does not rot so rapidly, since it is not dampened by the super-abundant moisture from the condensation of the steam. The mine is also well ventilated by this means and hence there is a greater efficiency of labor.

There are a great many machine drills on the market and each one has its admirers. Some miners will praise one, others like another. Among the most important in use in the Trail Creek District of British Columbia may be mentioned the Sullivan, Rand, Mac, Ingersoll and the Giant, all of which the writer has worked within the mine. One machine will work well in soft rock and not in hard rock, one will be better adapted to a certain class of work than another, but for all round work the Rand machine is perhaps the greatest favorite with the miners. It is strong and durable, will twist the drill, will throw its mud or dust from the hole, and works well on a moderate head of air. The Rand is a good machine in hard rock or ground, while in softer ground the Ingersoll will perhaps outdrill it. This latter-machine is a good economizer of air, while the Sullivan has an advantage over the others in starting a hole in a difficult place on account of its ability to run on a very short stroke.

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*Awarded a cash prize of twenty-five dollars in Mining Section, Student's Competition, 1903.

Because of the severe treatment to which these machines are subjected great care should be exercised in their selection. The two chief points to look for are strength and lightness. Most miners object to working with a heavy machine, and they do not take the same care of it that they would with one that they could carry about more readily. The cheaper machines are usually of poor quality and clumsy in construction, and if the rock is at all hard it is false economy to buy them. They are continually getting out of order and usually cost more in repairs than the difference in the price of a first-class machine. For softer rock, however, these objections to cheap machines do not apply with the same force.

The principal parts of a machine are the air-chest, valve, shell, piston, standards, side-rods, feed nut, feed screw and crank. It is by the motion of the piston backwards and forwards that drilling is accomplished, the drill being placed in the end of the piston, which is called the "chuck," and held there by a bolt called a "chuck bolt." As the piston moves it is made to turn from a seventh to a fifth of a revolution by means of a rachet and rifled arrangement, and it is this motion that prevents the drill from striking always in the same sense, and also throws the dust or mud from the hole. A common weakness in many machines is the rachet, and when a drill runs a little tight it does not turn, and the hole is "rifled." A machine that does not turn a drill *well* is useless, and is the cause of much profanity. Sometimes the side-rods break, which is usually due to the carelessness of the miner in allowing the piston to strike the head of the machine. At other times the shoe on the shell may give out or the piston may be snapped.

The drills, usually called "steel," are much stouter than hand drills, being about one and one-eighth, or one and one-quarter inches in diameter and octagonal in shape. The bits, called "diamond bits," are chisel bits placed in the form of a cross, and generally the steel is ribbed back from the bit a foot or more. This strengthens the bit and causes the drill to make a straighter hole, as without the ribs the drill has more chance to work sideways in the hole and finally cause it to stick. Often in drilling a dry hole, and occasionally in a wet one, however, a ribbed steel becomes tight, and a steel without much rib will run smoothly. Steel are of different lengths varying generally from eighteen inches or two feet to eight or nine feet, though sometimes much longer ones are employed. The gauge of the bit varies from three inches for the short drills to one and one-quarter for the long ones. In any hole each succeeding drill should be enough narrower in gauge to allow for the wear of the previous drill. If a fresh drill with sharp corners is put in, and fits the more or less rounded hole at the bottom rather tightly, the corners are very liable to break off, and thus cause trouble and delay.

Just here I might say that greater attention should be paid to the bits by the blacksmiths than is commonly the case. I have seen six foot drills so large in the bit that they would not follow after a four foot one, and the first drills, called "starters" so small that "seconds" would not follow them. Another common fault is in the tempering due to the carelessness or ignorance of the blacksmith, or to his being so rushed with work that he cannot turn out his drills in first-class shape. In hard rock poor bits will either break or batter up, and in this way much valuable time is lost. On the other hand we often see false economy on the part of the management because they do not supply enough drills for all the machines at work, and as a consequence many of the machines are idle simply for the want of steel to work with. Another great source of trouble is from the use of crooked drills. The crookedness may be in the body of the drill, or at the machine end called the "shank." When drills are crooked, especially starters, they make a larger hole than the gauge of the bit would warrant, and in the case of longer ones they will bind and thus stop the machine.

To assume a practical case we will say that a miner is given a job to go to work on a machine. He is told where to go, but is generally given little information, and he hunts around for the place and perhaps finds it by the time the shift boss arrives on the scene. Suppose he is told to work in a drift. The first thing to do is to set up the machine bar or column, and the problem is to place it in such a position that the holes may be drilled from it with the greatest convenience. It may be set up either vertically or horizontally. The general procedure now-a-days is to place it horizontally, in a face that is being worked continuously. This saves shovelling the broken rock from the previous blast out of the way, and thus the mucker removes the muck instead of the machine men. Of course, if there is no muck in the way it is best to set the bar upright as it makes a more rigid set up than if the "cross-bar" is used. It was formerly the custom, and it is still in vogue in some mines, for the machine men to shovel enough muck back to admit of an upright bar being used, and thus save a second rig up. It is generally the quickest and easiest, however, to rig up horizontally and drill all the upper holes, and then tear down and rig up again for the lower holes or "lifters." A cross-bar is usually placed about the length of a pick handle from the top or "back" of the drift and the same distance or a little more from the face of the rock to be drilled. It must be far enough from the face to allow room to get the drills in and out of the chuck, high enough up so that water can be used in most of the holes, and yet not too high to prevent a steep pitch being given to the holes that are blasted first. This pitch is also limited by the crank of the machine coming in contact with the back. A rigid set up is very important, and to secure it all blocking must be firm and well placed. The metal of the column must never come into contact with the rock as when jagged it would break. A plank or block of solid wood is inserted between the end of the column and the rock and tightly wedged. The cross-bar is then jacked by means of a lever or "jack bar" as tight as two men can make it. Something is then inserted in the end of the jack-screw to prevent it unscrewing. The bar must be watched from time to time as the jar of the machine in operation tends to loosen it.

If an upright column is used an arm is attached to it, and a clamp, upon which the machine is held, is fastened on the arm. This combination of arm and clamp allows, by its motion, up and down and around the column, the placing of holes in any part of the face of the drift. The arm is often used on the cross bar in drilling hard rock as it permits of more motion when a drill sticks in a hole, than if the clamp is placed directly on the bar.

The machine is now placed on the clamp, connected with the compressed air pipe by means of a hose, a drill placed in the chuck and the operation of drilling is ready to begin. The air supplied to the machines should be as dry as possible. The moisture is generally removed largely by means of receivers both near the compressor plant and also in the mine. Even then under favorable conditions the valves of the machine become clogged with ice. The pressure of air varies considerably but usually ranges from 75 to 100 pounds per square inch. Between 90 and 100 pounds is a good working pressure for most machines. Too high a pressure may cause damage to drills and machine, while too low a pressure is inefficient, as the drill pounds on the rock without making much headway.

The first hole is a dry hole, called an "upper," which is drilled with slight inclination upwards, and consequently water cannot be kept in it. In starting to drill a hole some precaution must be taken. If the rock is very hard and the drill strikes it obliquely, a short stroke should be given to the piston and only a partial head of air, as otherwise the drill or piston-rod might be broken. The hole usually works to one side and the machine must be adjusted to suit, or the hole will "run" and be lost. When the bit of the drill is striking the hole fair a full head of air may be turned on. Sometimes it happens, especially in a dry hole, that the drill strikes a slip in the rock, or a place where one side of the hole is softer than the other, in which case it works to the soft side and often binds the drill so that a new hole must be started. Often the miners put a piece of hard wood, or a piece of iron such as a nut or track spike, in the hole and let the drill pound on that. This enlarges the hole and generally remedies the evil, though it is rather hard on the drill.

Two "uppers" are usually drilled, three "breast" holes with just enough dip to hold water, three "cut" holes, which are as steep as they can be made, and two "lifters" with a slight dip, at the bottom. This makes ten holes altogether, but if it is hard ground to break, two more holes may be put in as relievers. When drilling holes downwards water is put in them, as it makes a mud which is thrown out by the drill, and thereby cleans the hole. Sometimes in soft ground the mud is formed so fast that the motion of the drill will not throw it out, in which case the machine must be run on a lower head of air. It may be even necessary to crank back and allow the drill to churn the mud so as to mix it with the water, when with a good machine, it will usually be thrown from the hole. Some ore is difficult to mix with water and hence the above trouble. This difficulty is seldom met with in the Trail Creek or Boundary Districts of British Columbia, as the rock is generally very hard, especially in Trail Creek.

Water for drilling is obtained at some convenient place and brought to the face in all sort of vessels, such as nail kegs, coal oil. tins, buckets, and even in powder boxes. A very convenient water bucket is made from 6 or 7 inch galvanized pipe. The pipe is cut into 20 inch lengths, a bottom of wood fitted into one end, and an iron bail fastened on the other. The best method of getting the water into the hole is by the use of a "gun." This is simply an ordinary squirt gun made from a heavy one inch pipe, and the water is squirted into the hole through a small aperture in one end of the gun. When a gun is not to be had an old tin can will answer the purpose, but is not as effective as the gun, and wastes more water, which is sometimes an item to be considered.

The supply of steel to the machines is often a source of annoyance to the machine men. The sharp drills come down in the morning, and the men get their supply which may be supplemented by some more at noon. By the time of change of shift at three or four o'clock, the drills are nearly all dulled if the supply is at all limited. Most mines have a man, called a "nipper," to gather up the dull steel, and before very much of it is sharpened the blacksmiths on the day shift are off and the next shift does not come on until seven o'clock. During this interval and often as late as nine or ten o'clock, drills are not to be had for all the machines. As a consequence the miners must work with dull steel, or else wait for more, and sometimes they prefer to wait. It will be at once recognized that this militates very much against economical mining, and it behooves the management to have a *liberal* supply of sharp steel always on hand.

Short drills with large bits are used to start the holes and, as the process of drilling proceeds, longer drills are put in. The increase of length in each successive drill depends upon the hardness of the rock, and the durable quality of the bit of the drill. If the rock is not too hard the drill may be cranked forward the whole length of the feed screw, which is about two feet in most machines, though a few large ones run two feet and a half. Thus for a six or seven foot hole about four drills would ordinarily be used, while if the ground is very hard as many as twenty might be necessary, the greater proportion being starters. When the ground is hard the piston-like motion of the drill in the hole causes the guage to wear away, so that each succeeding drill must be a little smaller in guage. Great care must be taken by the chuck-tender in this particular or the hole is liable to become so small that he will not be able to get the drill to the bottom of it.

The mere operation of drilling is the same whether in shaft, stope, drift or raise. Any difference that may arise would be caused by the condition of the set up and the consequent placing of the holes. Often in stopes considerable blocking is needed if the bar is not very long, and there is no muck present to set up on. Usually the stope is carried forward in such a way that a certain amount of muck is left on the timbers to protect them from blasts, and a bar about six feet long is a convenient length. A long bar requires that the miners shall spend some little time mucking in order to rig up after a blast, if the face is being driven continuously, while a very short bar necessitates the building up of a pile of blocking. This usually consists of 3x12 inch planks about 5 feet long, 8x10 timbers, or, if these are not supplied, as is often the case in many mines, anything that comes to hand. In a stope the holes are placed much farther apart as the ground has a far better chance to break. The placing of the holes depends on the breaking qualities of the rock, the strength and proximity of timber, and its protection from the blast, and the amount of powder it is safe to use under the circumstances in each case. This knowledge can only be obtained by experience combined with sound judgment.

An upraise is perhaps the most difficult and dangerous face to drive. It is difficult because the holes must always be drilled dry, and a dry hole cannot be put in as quickly or as easily as a water hole. It is dangerous because it necessitates a good deal of climbing up and down under loose rock after blasts, working from stagings, and often in bad air. After blasting it is necessary to put up a staging to work from in order to get to the face and pick down the loose rock, and while it is being erected the miners must work under this "bad ground."

Before rigging up in a raise the back should be thoroughly picked down and a good staging established This consists of two poles tightly placed between the foot wall and the hanging wall of the raise, and covered with planks or round lagging. The column is always placed cross-wise in a raise, that is from foot to hanging wall, with an inclination depending upon the dip of the vein or face of the walls. It must always be placed just far enough from one end to allow good cut holes being drilled, and about two rows behind these to bring out the requisite amount of rock. After these holes are finished the machine is torn down and re-rigged in the other end of the raise. In the second rig-up it may only be necessary to drill one row of holes, especially if the raise is small. It is not good policy, however, to carry the raise too small, as it does not permit good cut holes being drilled, and these are always the most important because if, on blasting, they fail to break the other holes cannot possibly do so.

Drilling in a raise is disagreeable on account of the dust, which is more or less blown about by the air from the exhaust. When the proper number of holes, called a "round," is completed, the machine is torn down, as well as most of the staging, and placed just below on the top stulls, if they are not to close to the blast, and carefully covered with planks.

The drilling in a shaft is just the same as in a raise only the holes are all water holes, and no staging is needed. Here again the work is somewhat dangerous, as anything might fall from above such as rock, or drills, or the bucket might upset in its descent, etc. There is little mucking to be done in a raise, while in a shaft the cut holes are blasted and mucked out first, and then the other holes are treated.

Before blasting in any face care should be taken to see that no damage will result. Any exposed air pipe should be protected from flying rock, and the floor of a stope should be covered in such a manner that the broken rock resulting from the blast may be handled with the greatest possible advantage. In a drift a floor should be laid down consisting of a number of planks partially covered with muck to protect them from derangement by the blast. A better practice is to lay down large sheet iron plates, 4 x 8 feet being a convenient size. This floor is of great assistance to the mucker, as he can shovel easily, and he can run his car on the plates, and thus have it close to his work. More attention and forethought in this direction would often result in a larger output per man than is commonly the case.

Blasting is an important part of the work and requires skill on the part of the miner in being able to judge the amount of powder necessary to break the rock without doing damage to the timber, air pipes, etc. Of course, in all places except stopes there would not, as a general rule, be much danger of doing damage with too much powder. If, on the other hand, he used too little powder the rock would not be shattered, and the holes would need to be reblasted, thus causing a waste of powder. I have often seen two boxes of powder used in a drift where one would have been sufficient, either through the incompetence of the miners themselves, or by reason of the short-sightedness of the management, who often try to keep the powder bill low, with disastrous results as far as economical blasting is concerned.

The amount of powder necessary to blast a round of holes in a drift depends upon the number and depth of the holes and the breaking quality of the ground. From seven to ten sticks are generally used to a hole, although there are cases where as few as four would be enough, and then again as many as twelve or fourteen might be necessary. Each stick is about an inch in diameter and ten inches in length. The cuts and lifters are always blasted first, and then, if they break well, the remaining holes are set off.

After the machine and column are torn down and placed in a place of safety, the holes are blown out with a "blowpipe," which consists of a bent gas pipe about eight or nine feet long having a valve and connected with the compressed air pipe by means of the machine hose. The holes are then ready to load. The sticks of powder are slit with a knife along one side, placed in the holes one by one, and tamped down snugly with a long wooden "tamping stick." The usual custom is to fill the hole all but two sticks when the "primer" is inserted. This consists of a cap containing fulminate or mercury, into which is inserted the end of a fuse, the end of the cap being nicked into the fuse by a pair of pincers, to prevent it from being detached. A hole is made in the stick of powder with the miner's candlestick, and the capped fuse is pushed in to about the centre of the powder. This powder, cap and fuse constitutes the primer, which is lightly tamped into the hole, and another stick tamped well on top of it. Some fine rock, or paper, or old gunny sacks, may then be put on top of the powder by way of "tamping," so that the force of the explosion will not be directed so much out of the hole, and also to make it safer from flying sparks when the fuse is lighted.

The fuse, which is from five to eight feet long, depending on the chance the miner has for getting away from the blast, consists of black powder with wrappings of different kind to make it strong and impervious to water. The kind usually used burns about one foot per minute. The fuse is coiled up close to the collar of the hole, or even placed within it, to prevent it being cut off by flying rock. The fuse, when first put in, are all of the same length, and when all the holes are "loaded" a portion is cut from the end of each fuse in such a manner that the hole which has the best chance to break will be blasted first, and a little less is cut from each succeeding fuse. The difference in length is about an inch or an inch and a half, and the fuse are all lighted in the same order in which they are supposed to break. This insures their going off in their proper turn.

When the fuse is properly placed and everything is in shape to blast, the end of each fuse is split with a knife so that they can be lighted easily. The process of lighting them is called "spitting," and they may be "spit" by means of a candle, but the better practice is to take a short piece of fuse, cut it diagonally half way through at intervals of about three quarters of an inch, and light this. As the powder burns to each cut the fire flies from it, and, by holding it near the split end of the fuse, it lights it immediately, while with a candle it often takes some time, especially in wet places.

Sometimes a novice at the art of blasting becomes somewhat excited when the burning powder from the fuse begins to fly around him, and he will spit the wrong one first with the result that the blasting does not do the execution it should. Sometimes when one hole breaks, it also breaks away part of another hole, and takes with it the fuse and part of the powcer. When this happens, of course, powder is left in the second hole which does not explode. Rock is thus left in the way of the succeeding hole, and causes more or less reblasting to become necessary. Sometimes, again, the holes have not been well placed and the hole does not break to the bottom, leaving an enlarged hole called a "bootleg" or "bottom." If these bootlegs are very deep they may be reblasted, but generally they are left. Again, it often happens that the powder will burn and not explode at all, in which case there is a complete hole to reblast, or the fuse may only burn part way, and hence not cause the detonator or cap to explode the powder. When a hole burns out it can generally be detected by the smell. The cut holes are blasted first, then lifters, breast holes and uppers, in the order named.

Blasting in all other places is very similar to that in drifts. In stopes more care must be taken and not so much powder used, as the ground breaks easier and it would come down in such large slabs or blocks as to break the timber. It would also shatter the roof badly and make it a source of danger to those who work beneath it. Any bowlders too large to break with a sledge hammer are blasted by laying powder on top of them, and firing without having holes drilled in them. This is called "sand blasting," or vulgarly "bull-dozing." If the bowlders are very large it may be necessary to drill holes in them with hand steel, and this is called "block-holing."

Simultaneous blasting by means of an electric battery is not resorted to in any of the several mines in which the writer has had experience. The reason probably is that this method is not as convenient nor as rapid as the fuse method, and also because the advantages derived from its use are reduced to a minimum by arranging the holes more or less irregularly so that one relieves another. Thus the principle underlying electric firing scarcely enters the problem. It is not adopted in stopes because of the system of timbering, and a simultaneous blast would bring so great a weight suddenly on the timber that damage would result.

Ventilation is an important feature of mining where large amounts of explosive are used. The smoke does not occasion very much trouble, as it soon makes its way out, but it is not so with the gas. To get rid of this nuisance the air is turned on by means of the hose or at the air pipe connection, but this method requires time and is not very efficient. A better arrangement is to carry a line of galvanized piping into the mine, and have connections made with the drifts, cross-cuts, raises, etc. These lines of pipes are led along the drifts and supported on light scantling overhead. A connection is made with the air pipe at the proper place to cause a draught through the ventilating pipe thus causing a suction of air and gas from the drift. In this manner, a working face may be very soon cleared of bad air, and consequently a great saving of time is accomplished. If a miner is compelled to work in vitiated air, he labors at a great disadvantage, and slow progress is the result.

After blasting in any face there is always more or less loose rock to be taken down from overhead. This is done by means of picks, hammers and long steel bars called "pinch bars." It is always the miners duty to examine the back very carefully and take down all rock that is "drummy," or has a hollow sound when tapped lightly with a hammer or bar. At times it becomes necessary to blast where a large crack is developed, as large slabs may be hard to get down, yet at the same time they are dangerous, and may fall at any moment, or may be jarred loose by a blast in another part of the mine. Barring down loose rock is very hard work, and often consumes a great deal of the miners' time. In some places a whole shift may be occupied in this way, but generally about an hour in a stopė is sufficient to make the back safe for those who must work beneath it.

The powder used depends largely on the work it is expected to do. Two varieties are generally provided, the better being 60% nitro-glycerine and the other 40%. In pure development work, as drafts, raises and shafts, the 60% is used, because it is here that the rock does not have as good a chance to break as in a stope, or the ground is said to be "tight." The 40% variety is adopted in stopes where the rock breaks easier and it would not be advisable to shoot off heavy blasts on account of the timber.

Sometimes the management will try to break a round in a drift with 40%, but as far as my observation goes it always costs them more in the end than if they had used the 60%. The men have a certain length of time to drill the round, generally two shifts, and there is a limit to the number of holes that they can finish. Any lack of holes must be made up by using more powder. It is cheaper to use too much powder than too little, because, if a hole is reblasted it means that it requires at least one and a-half times as much powder as it would if enough had been used the first time.

The powder is thawed on the surface and brought down into the mine, generally about eleven o'clock at night, when it is distributed to the miners by the night blasters along with the fuse required. The miners blast just before going off shift, and the night blasters go around later and fire any missed holes, burnt holes, or holes that did not break, as well as sand blast any large bowlders that they can reach. Some mines have a "powder monkey" to cut and cap fuse and tend to the powder as well as keep an account of all blasting material used.

The men engaged in mining in the West are an excellent class of men and hail from all parts of the world. There being so many fluctuations in mining operations and a certain amount of uncertainty in connection with mining camps, the men who follow this more or less hazardous occupation are continually moving from place to place. Then again the miner is not sure of his job from one day to the next. He may be discharged at a moments notice, the mine may be shut down as part of a stock-jobbing scheme, or for want of ore. He may lose his job through a change of management, because he belongs to a union, or the reverse, or from various other causes. Wages under such conditions are necessarily high, ranging from $2.50 for the ordinary laborer to $3.50 or $4.00 for the skilled miner. Though the wages are comparatively high, the men are little better off than their brethern in the East, on account of being out of employment so much of their time, and also because of the excessive cost of living, especially if they have families. Most of the men usually belong to a union, which is a fraternal organization. Indeed, it is a noticeable fact that the better class of miners are union men.

In the foregoing paper I have merely touched on the processes of drilling and blasting. Much more could be said about these operations, and many more points brought out that are met with in practice. Many difficulties attend the work of miner, the former being overcome by perseverance and the knowledge that comes of long and intelligent experience, and the latter may be averted in great measure by carefulness, both on the part of the miner himself and on the part of the mine management.

On the Manufacture of Sulphuric Acid at Sydney, C.B.

By C. A. Meissner, Sydney, Cape Breton.

The manufacture of sulphuric acid for the purpose of making sulphate of ammonia, or the uses in the sulphite wood pulp industry, is one of the branches of the coke department where coke is made in patent ovens and the by-products are saved. Ammonium sulphate is made from the ammonia in the gas from the ovens, which is washed out and the resulting gas liquor is mixed with milk of lime which liberates the fixed ammonia and passed through suitable stills where it comes into contact with steam. By this means the free and combined, or fixed, ammonia is given off in gaseous form, and then passed into sulphuric acid contained in lead lined tanks. This acid is the ordinary chamber acid of 54° to 55° Beaume diluted down to about 42° Be.

Usually the sulphuric acid is made near the by-products plant in which it is to be used, unless commercial acid is readily and economically available, and distances from acid factories and subsequent freight rates are not too high.

Sulphuric acid is made largely out of iron or copper pyrites,—$Fe S_2$ and $(Cu_2 S) (Fe_2 S_3)$—also from native sulphur. In some cases the nickeliferous pyrites are roasted and the nickel subsequently extracted, as well as the copper. Arsenical and auriferous pyrites are used in some cases and the arsenic and gold extracted. Zinciferous sulphur ores are beginning to be largely used for this purpose, and are liable to become an important factor. Native sulphur running from $17 to $20 per ton is, as a rule, too expensive against the price of pyrites containing 50% sulphur at $4.50 to $6.50 per ton and is used when not too far from source of supply. In this country it is largely used in the manufacture of the sulphite wood pulp process. Strong efforts have been made to find additional native sulphur deposits besides those now well known, but so far no new large deposits have been brought into the markets and the price of native sulphur has not been reduced much in late years. The deposits in some of the

West Indian Islands, and also some of the Alaskan group of Islands, are not yet figuring in the market to any extent.

So far, in the States, the importation is nearly double the home production.* In Canada comparatively small amounts of pyrites are mined, something over 35,000 tons being the total production for 1902. This comes largely from the mines at Eustis and Capelton in the Eastern Townships of the Province of Quebec. As yet no iron pyrites mines have been discovered that are of any extent, although the whole country, especially in the Lower Provinces, is heavily impregnated with pyrites in small particles, seams, or pockets, in practically all classes of rock. New locations in Lower Canada have been examined, but so far without direct economic success.

Newfoundland has produced some large deposits, some of which have already stood the test of time. Others, however, are still in the development stage, and later I will describe some of the deposits in the Labrador Districts which give promise of being large producers after being properly developed. The Pilley Island deposits in Notre Dame Bay, Newfoundland, are again producers, after having been idle for a number of years. At one time it was a well known deposit, having produced over 400,000 tons before being shut down. It, like nearly all Newfoundland pyrites, is very pure as far arsenic is concerned, and usually high in sulphur.

Physically, these Newfoundland ores are largely hard and fairly compact, some exceedingly so, as for instance the Labrador varieties, and with care the amount of fines is not excessive.

Copper pyrites are worked on a paying basis in several locations in Newfoundland, and such mines as Tilt Cove and York Harbour are, and promise to be, steady producers. York Harbour in the Bay of Islands, particularly, promises to be a large and steady producer. Along the Labrador Coast, pyrites deposits have been reported, of which the Rowsell's Harbour deposit is, so far, the only one that has been carefully investigated. This is the one that I will describe fully later.

From this preliminary sketch on the sources of supply, we will now turn to the manufacture of sulphuric acid at the Dominion & Steel Company's Acid Plant, in Sydney, Nova Scotia, as described by Mr. C. Carter, Superintendent of the Plant.

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*See Mineral Industry.

The manufacture of sulphuric acid, as at present carried out by means of what is known as the chamber process, is the result of many years of study and observation, combined with the application and adaptation of materials and methods to the circumstances existing from time to time. Whilst other processes for the manufacture of acid have been brought out and developed, the chamber process remains to this day the most important of them all.

The object to be attained in this and other processes is to bring about the combustion of sulphur dioxide gas (SO_2) derived from the combustion of sulphur with the elements of water (H_2O) and an additional atom of oxygen (O) to form sulphuric acid (H_2SO_4)

$$SO_2 + H_2O + O = H_2SO_4$$

As a chemical equatation, this reaction appears to be of the simplest kind, but as a matter of fact and practice, the combination does not occur in quite such an easy manner, for, whilst the first part of the reaction, viz., the combination of the sulphur dioxide with the water, is readily brought about with the formation of sulphurous acid (H_2SO_3), the greatest difficulty is experienced in getting this sulphurous acid (H_2SO_3) to combine with the extra atom of oxygen to form sulphuric acid (H_2SO_4).

The principal sources of supply of sulphur for the manufacture of acid are (1) brimstone, (2) iron and copper pyrites, and (3) spent oxide from the purifiers of gas works. Of these the pyrites are by far the most important sources, most of the acid at the present day being made from these substances.

It may here be convenient to give a brief outline of the process, returning afterward, to discuss more closely each stage of the process in detail. Broadly speaking, the pyrites are burnt in suitable kilns or burners, and sulphur dioxide gas given off. This gas passes along through a flue into the nitre oven where a mixture of nitrate of soda and sulphuric acid is decomposed by the heat of the burner gas, and nitric acid vapours given off which travel on with the burner gas into what is known as the Glover tower, the object and working of which will be described later. The gas rises through this tower and passes from the top through a flue into a series of leaden chambers, where it comes into contact with water vapour in the form of steam introduced through the sides or tops of the chambers. In these chambers the reaction between the gases and steam takes place, resulting in the formation of sulphuric acid which falls to the bottom of the chambers as a fine mist, where it accumulates as a liquid known as chamber acid. From the last of the series of chambers, the residual gas passes through another flue into the bottom of the Gay-Lussac tower, up which it rises, and in which the greater part of the nitrogen acid gases derived from the nitrate of soda are recovered and made available for being used over again. From the top of the Gay-Lussac tower the remaining portion of gas, which consists almost entirely of air, passes out into the surrounding atmosphere.

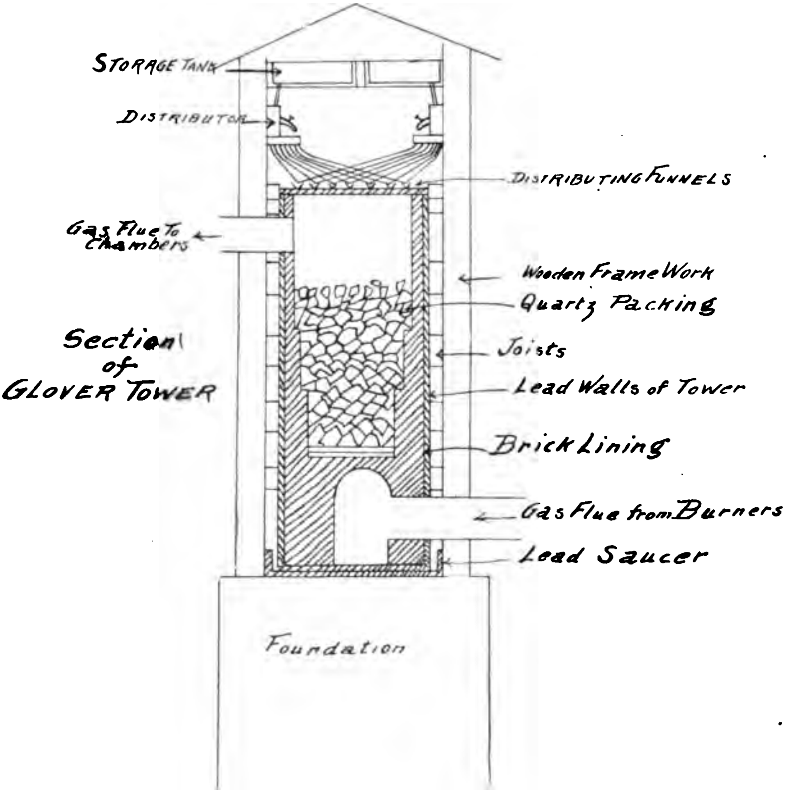
Having given this very brief sketch of the process, it may now be convenient to discuss each step more in detail.

The kilns, or burners, in which the pyrites are burnt are usually built in sets, back to back, of 12 to 24, or more, burners, and are constructed of brick lined inside with firebrick. The internal dimensions are about 8 feet high, by 4 ft. 6 ins. wide, by 5 ft. to 6 ft. deep. About 2 feet from the ground is placed a set of grate bars. each bar being free to move around its axis, so as to allow the burnt cinders from the pyrites to pass through. The front of the burner consists of a cast iron plate fitted with three tiers of doors, the lower one being placed convenient for removing cinders from below the grate bars; the next higher on a level with the grate bars so as to enable the men in charge to get at and turn around from time to time. The upper door is placed about three feet higher, and through this the charging is done. It is fitted with a small sliding door to enable the interior of the burner to be observed without having to open the larger door. In the roof of the burner is a square hole about 12 inches square communicating with a flue passing along the whole length of the set of burners, and into which every separate burner discharges the gas from its pyrites.

In starting up a set of such burners, a layer of cinders is placed on the grates about 18 inches in depth, on which the pyrites is ignited by suitable means, the charge of ore being about 700 lbs. for every twenty-four hours. Each burner in a set receives attention in rotation every twenty-four hours, the cinders being shaken down into the ash pits, and a fresh charge being put in on top, the new charge being ignited by the heat of the previous charge. In the ash pit door are some small doors capable of being regulated, through which the air required for combustion of the sulphur is allowed to enter.

The heated gas from these burners, which consists essentially of a mixture of sulphur dioxide and air, passes through the flues into the nitre oven. This is an enlargement in the flue containing two cast iron pans set in in such a manner that the heated gases can play well over and around them. These pans are about 7 ft. long by 2 ft. wide and 1 ft. deep. Through an iron door in the wall of the oven charges of nitrate of soda, together with sufficient sulphuric acid to completely decompose the nitrate, are introduced at regular intervals. The heated gases warm up this mixture and keep the reaction going. Nitric acid gas being given off, which is carried off along with the burner gases into the next stage of the process. The sodium sulphate ($NaHSO_4$) resulting from the action of the sulphuric acid on the nitrate of soda is withdrawn from time to time through a channel in the bottom of the pan, and is allowed to cool and solidify. In some cases this substance is utilized by working it up with common salt into salt cake in the manufacture of carbonate of soda, and also in glass making, but in many places it is useless and simply thrown away.

The gases which leave the nitre oven next pass into a tower called after the name of its inventor, the Glover Tower. This tower consists of a hollow column of sheet lead, from 20 to 30 ft. high, and 9 or 10 ft. square, held in an upright position by a strong timber at each corner carrying joists to which the lead is attached by straps of the same metal. The lower end of the lead tower stands in a saucer made of the same

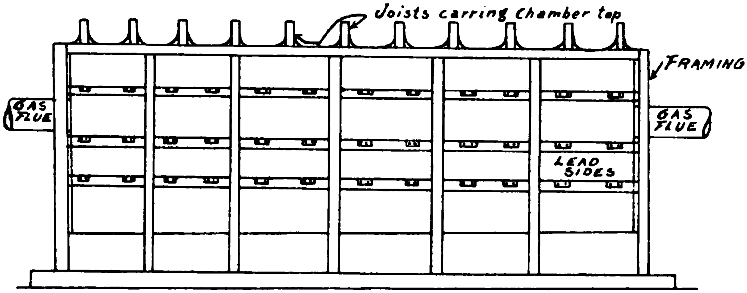

STORAGE TANK
DISTRIBUTOR
DISTRIBUTING FUNNELS
Gas Flue To Chambers
Wooden Frame Work
Quartz Packing
Section of GLOVER TOWER
Joists
Lead Walls of Tower
Brick Lining
Gas Flue from Burners
Lead Saucer
Foundation

material, about 1 ft. wider every way than the lead column, and about 1 ft. deep. This saucer is provided with a lip on one side to carry off the acid which runs through the tower and out at the bottom. The interior of the tower is lined with a glazed metallic brick, such as will resist the action of the acid, This brick is built up into the form of an arch over the pipe which brings the gas from the burners, the roof of the arch being arranged as a grating to break up the gas into a number of streams. The walls of the tower are then lined with the same brick up to the top, the lining being graded upwards from a brick and a half thick at the base to half a brick at the top. These bricks are all laid dry without mortar or cement of any kind. The space within the brick work is then filled in with quartz or flints, graded in size from the largest pieces at the bottom to the smallest sizes at the top, the packing being filled in to within about 4 ft. of the top of the brick lining. The top of the tower is covered in with a sheet of lead which is perforated with a number of holes placed about 2 ft. apart over its surface and fitted with funnels and lutes in such a way that acid can flow down into the tower without allowing the gas to pass up through the lutes.

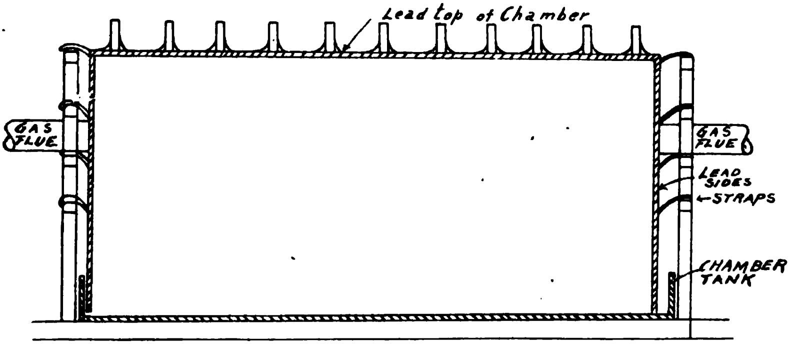
Above the top of the tower is erected a chamber containing two distributers and storage tanks of lead for holding and delivering the acids which are allowed to run down the tower. The distributers are of many kinds. the main idea being to divide up the stream of acid from the storage tank into, a number of fine streams of uniform amount and deliver these at the different holes in the top of the tower. In the side of the tower above the brick work, and below the top sheet, a leaden flue is affixed to convey the gas from the top of the tower into the first of a series of chambers. The objects of the Glover Tower are two-fold : (1) to denitrate the nitrous acid obtained from the Gay-Lussac tower in a later stage of the process, and restore the nitrous gases to the system; and (2) to concentrate the acid running down the tower. These objects are attained as follows:—

Strong sulphuric acid, containing nitrous acid gases in solution, possesses the property of giving off these gases as reddish fumes when

ACID CHAMBER



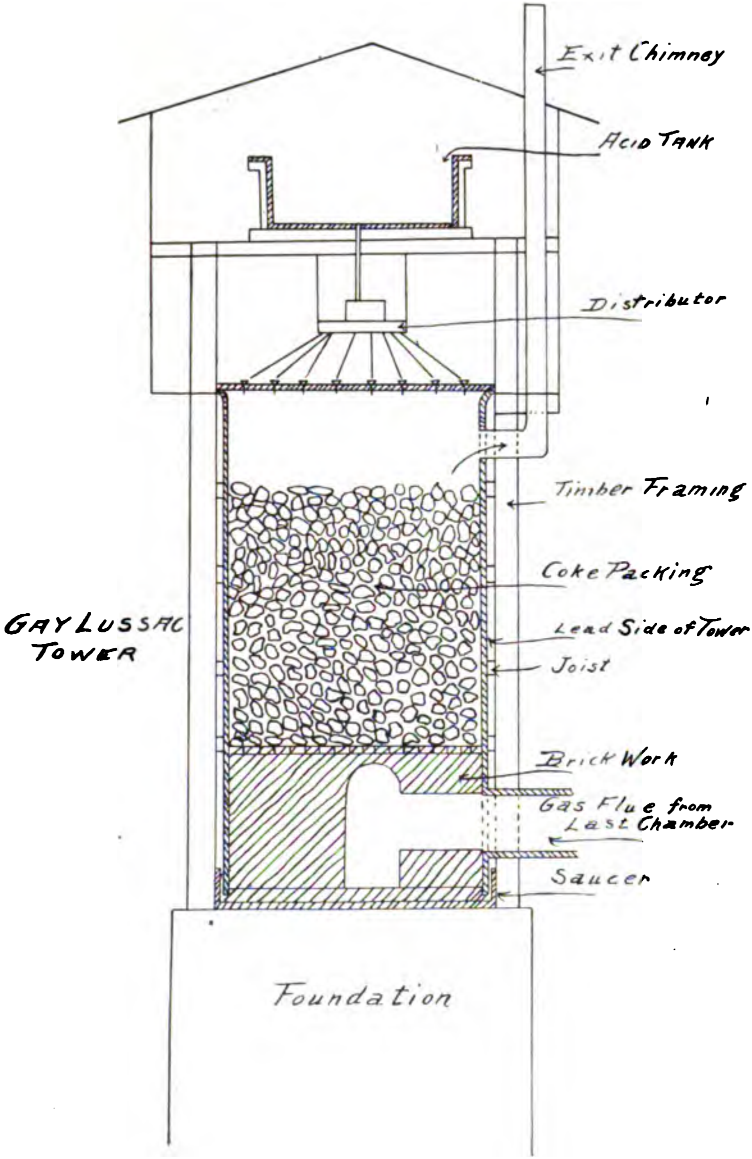
ELEVATION



Section

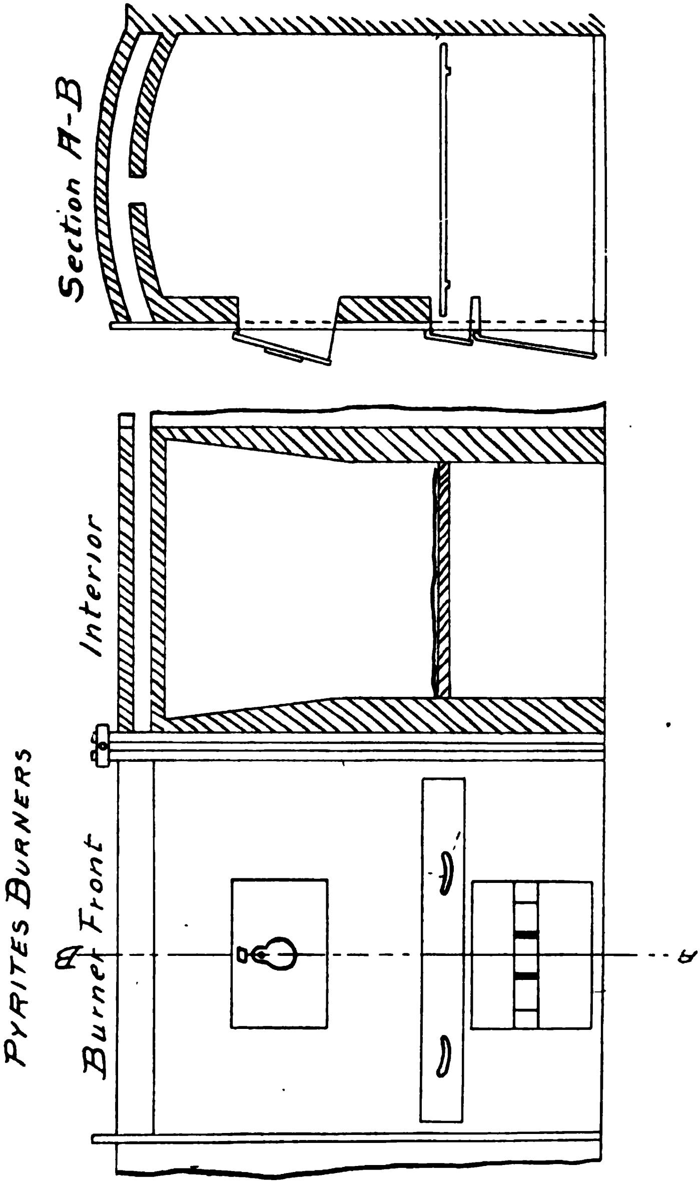
it is diluted with water or a weaker acid. Advantage is taken of this property in the Glover tower by having two tanks at the top, one containing the nitrous sulphuric acid and the other water or weak acid from one of the chambers. Various names are given to this nitrous sulphuric acid. By some it is known as nitroso-sulphuric acid, whilst in the trade it is usually termed nitrated acid or nitrous vitriol, the last name being used hereafter. A pipe from each tank leads to one of the distributers, the nitrous vitriol being piped to one, and the water or weak acid to another. A stream of water or acid is started, and both mix at the funnels leading into the tower. The acid on dilution gives up its nitrous gases which are carried into the chambers again by the ascending column of gas. The mixed liquids fall down on to the quartz packing and are divided up into countless little streamlets descending the tower, and cooling the gases as they rise through the interstices of the packing. Lower down the gases are hotter, having just left the burners, and here the heat is sufficient to drive off the water from the descending shower of acid and returns it as steam to the chambers, whilst the acid runs out into the saucer at the base of the tower, and from there into the storage tank, as strong as it was before dilution at the top of the tower, and at the same time deprived of the nitrous acid which it formerly contained. The degree of denitration and concentration is regulated by varying the supply of water or weak acid at the top of the tower, the acid running away from the base of the tower, being tested frequently for strength and nitrous acid. If this shows a high test for nitrous acid, more water or weak acid is required, whilst if the strength is below the normal, some water or weak acid must be cut off. The acid which runs off from the base of the tower is passed through a cooling arrangement to reduce the temperature as much as possible, and is then in a suitable condition to be used over again in the other tower or Gay-Lussac tower in a stage to be described later.

The mixture of gases which reaches the top of the Glover tower and which consists of sulphur dioxide, nitrous acid gas (N_2O_3), steam and air pass through the flue into the first set of chambers, the tem-


Exit Chimney
Acid Tank
Distributor
Timber Framing
Coke Packing
Lead Side of Tower
Joist
Brick Work
Gas Flue from Last Chamber
Saucer
GAY LUSSAC TOWER
Foundation

perature of the entering gases being about 140° F., though it sometimes falls as low as 100° F. in very cold weather, such as we occasionally experience in Sydney.

The chambers, which have been mentioned previously, are enormous receptacles constructed of sheet lead. They are usually built in sets of 3, 4, or more, according to the capacity of the plant. Sometimes all the chambers are of the same size, about 90 ft. long by 24 ft. wide and 24 ft. high, containing about some 50,000 cubic feet of space each inside. In other plants, as at the Dominion Iron and Steel Company's plant, the chambers are of varying sizes, the first chamber being the smallest and the last one the largest. There is not, however, any distinct advantage apparent of one plan over the other. The Steel Company's plant consists of three chambers, the first one being 36 ft. long, 25 ft. wide and 20 ft. high, having a capacity of 18,000 cu. ft.; the second being 117 ft. long, 25 ft. wide and 20 ft. high, with a capacity of 58,500 cu. ft.; and the third being 150 ft. long, 20 ft. wide, and 20 ft. high, with a capacity of 60,000 cu. ft.; the total contents of the three chambers being 136,500 cu. ft. In the construction of these chambers, the base of each chamber is essentially an immense lead tank, with sides two feet high. Into this the leaden sheets forming the sides of the chamber hang almost touching the bottom of the tank, the acid formed in the tank acting as a lute around the lower edge of the sheet to prevent the gas from escaping. The top of the chamber is a lead sheet. The sheets are joined together by burning, a blow pipe, using oxy-hydrogen gas, being used to melt the edges of the sheets sufficiently for the metal from the two sheets to run together and solidify. Solder would be of no use, as it would not resist the action of the acid gases. The leadwork is held up by a strong wooden framing, built up all round outside, to which the sides and top of the chambers are attached by lead straps burnt to the sheet lead and nailed to the joists. A set of chambers is usually raised some ten or more feet above the ground to allow for a natural fall of the acid when drawing it off from the chambers for use. The chambers are connected one with the other by means of leaden flues about 2 to 3 ft. in dia-


PYRITES BURNERS
Section A-B
Interior
Burner Front
a
b

meter through which the gases travel from one chamber into the other. Each chamber has several fittings. First of all one or two steam jets are inserted in the sides or top connected outside with a steam supply and valves so that the admission of steam can be controlled. On one side of the chamber at intervals of 20 ft. or so, a tray 10 ft. long by 1 ft. wide is attached inside the chamber about 5 ft. from the bottom. This tray is placed on a slope of about 1 in 12, and at the lower end a tube of about 1-in. bore communicates with the tray and the outside of the chamber by passing through the side. When the chamber is working, some of the condensed acid collects on this tray and runs out by the tube where it is received in a hydrometer glass and tested for specific gravity at regular intervals, by means of which it is known whether too little or too much steam is being admitted. Thermometers are also inserted through holes in the side to indicate the temperature of the interior and a place is made at each chamber either by means of a manhole or by pressing back some of the leadwork for obtaining samples of the acid standing in the bottom. In these chambers, the formation of the sulphuric acid takes place. Various theories have been advanced for explaining the formation, none of which, however, can be accepted with absolute certainty. The most generally accepted theory, however, is that the sulphur dioxide (SO_2), the nitrous acid from the nitre ovens (N_2O_3), the oxygen from the atmosphere, and the steam generated in the Glover tower react in the first chamber producing nitroso-sulphuric acid in accordance with the equation—

$$2SO_2 + H_2O + O_2 + N_2O_3 = 2SO_2\,(OH)(ONO)$$

This nitroso-sulphuric Acid floats about the chambers as a mist, and on coming into contact with more water vapor from the steam jets is decomposed with the production of sulphuric acid, which sinks to the bottom of the chamber, and nitrous acid gas (N_2O_3) which is available for further reaction, this reaction being capable of representation by the equation—

$$2SO_2\,(OH)(ONO) + H_2O = 2H_2SO_4 + N_2O_3$$

Thus the nitrous acid gas acts as a carrier of oxygen, bringing about the combination of the sulphur dioxide with the extra atom of oxygen required to form sulphuric acid. This reaction goes on over and over again right through the set of chambers, the action of the first chamber being the most energetic, as shown by the higher temperature of that chamber, which in the other chambers gradually falls until at the outlet from the last one it is about the same as that of the atmosphere. It is the duty of the chamber attendant to go round the chambers every hour and observe the specific gravity of the samples obtained from the test tables inside, or the "drips" as they are called, and from these observations he judges whether more or less steam is to be admitted. The liquid acid, as it is formed, settles in the bottoms of the chambers, from which it can be syphoned off, whenever required, for any purpose for which it is made.

By the time the gases have reached the end of the set of chambers, the reaction should be theoretically completed, the residual gases consisting of nitrous acid gas (N_2O_3) and air only. In practice, however, this is never the case, there being always traces of unaltered sulphur dioxide in the gases leaving the chambers. In the early days of the chamber process, these gases were at once allowed to go out into the atmosphere, which meant that a large amount of nitrous acid gas was continually escaping and so being lost. Thanks, however, to the invention of the French chemist, Gay-Lussac, it has been found possible to recover the greater amount of this nitrous acid gas and render it capable of being used over and over again, and so economizing to an enormous extent the quantity of nitrate of soda formerly used.

Gay-Lussac's invention consists of a leaden tower called after his name, and constructed on very similar lines to the Glover tower. It is generally made considerably higher than the Glover tower, say from 40 to 50 ft., and is given either a square or a circular cross section. Its capacity is usually proportioned according to the size of the chambers, 1 p.c. of the capacity of the latter being a very frequent proportion, though an increase to 2 p.c. secures a very much more efficient scrubbing of the gas and a recovery of the nitrogen acids. In some cases, the interior of the tower is lined with brick, whilst in others no lining is used. The usual packing for the tower is coke. Ordinary gas coke is of no use, only the hardest burnt oven coke, giving a clear ring and as little porous as possible, of a silvery white, not of a dull black color. A third of the tower is filled with large pieces of the coke about a foot or so in length, then some pieces next in size, and for the last third smaller lumps may be used, but nothing which will go through a riddle with three inch holes should be allowed to go into the tower. The tower is covered in, in the same way as the Glover tower, and is provided with a distributing table and storage tank.

The principle on which this tower acts depends on the fact that strong sulphuric acid of 60° Be', possesses the property of absorbing nitrous acid when brought into contact with it, forming nitro-sulphuric acid, or the nitrous vitriol of the trade. It will be remembered that the acid obtained from the base of the Glover tower is strong, of 60° Be', and has been deprived of its nitrous acid. This is in a fit state to be used in the Gay-Lussac tower, to the top of which it is pumped and allowed to run down through it. This liquid meets the ascending gases and absorbs the nitrous acid contained in them, running out at the base of the tower as nitrous vitriol, available for use over again in the Glover tower, where the nitrous acid is restored to the process. It will thus be seen that the two towers act one with the other, the one absorbing the nitrous acid gas from the gases leaving the chambers, the other restoring it to the fresh gas entering the chambers, so that there is a constant interchange going on. The waste gases which reach the top of the Gay-Lussac tower should consist, theoretically, entirely of air. In practice, however, small traces of sulphur and nitrogen acid gases are always present, though, it is possible to keep them down to a very low amount. In Great Britain the Alkali Act prescribes that the escaping gases from the end of the process shall not contain more than four grains of acids calculated as sulphuric acid in a cubic foot. In practice it is quite possible to keep the acidity of the escape below this limit. At the end of the process is fitted the arrangement for producing the draft, which causes the gases to pass regularly from the burners to the Gay-Lussac tower. This may consist of a steam jet introduced into the exit pipe from the top of the tower, or else the exit pipe is carried down to the base of a tall chimney stack where a damper is placed to control the sucking action of the stack.

In a room at the base of the towers are placed the tanks for receiving the acids running from the towers, and the pumping arrangements for raising the acids to the top of the towers.

The successful and efficient working of the process depends very much on the regularity with which every operation, such as charging the pyrites and nitrate of soda, testing the drips around the chambers, running the acids down the towers, and controlling the draft is observed.

The manner in which the waste product from the nitre oven is disposed of has been mentioned.

The other waste product is the cinder from the the roasted pyrites called purple ore. In case this contains copper in paying quantities, 4 p.c. or above, it is usually shipped to the copper smelters for the extraction of that metal. When roasting copper ores it is usual to mix them with salt, which converts the copper into chlorides, but can be leached out with slightly acidulated waters, and the subsequently precipated copper smelted. The purple ore from copper ores after leaching is very free from sulphur, and in that way makes a very good blast furnace ore. The reason ores containing copper are more free from sulphur after roasting is because the copper oxide formed during the roasting reacts on the copper sulphide, according to the formula:

$$2\ CuO + Cu_2S = 4\ Cu + SO_2.$$

In case of iron pyrites this reduction to metal or self purification does not take place, but somewhere from ½ to 1½ p.c. of sulphur usually remains according to perfection of roasting.

When copper is below 1 p.c. or only in very small quantities, then the purple ore is usually higher in sulphur, as above shown. It is, therefore, not as good for blast furnace material, and yet is used very largely in furnaces that have not the burden with very high sulphur in their other raw material. In many cases where it is not desirable to use it direct as a part of the burden, it is used for damping down the bell of the furnace, so that it is incorporated with the charge in small quantities:

It may be of interest to show the analysis of some of the Newfoundland and Spanish ores and also analysis of some of the purple ores.

ANALYSIS OF PYRITES:

Description.	Iron.	Silica.	Sulphur.	Arsenic.	
1. Pilley Island..........	43.55	5.30	47.17	.29	
2. Fines from Acid Pit....	43.91	1.19	50.07	.27..	Moisture .38 Zinc 1.63 Copper .96 Alumina .37 Lime .60 Magnesia .51
3. Pilley Island..........	44.04	3.42	49.03	.09	
4. Pilley Island....			51.04		
5. Pilley Island..........	40.51	4.68	46.98	Trace	
6. Pilley Island..........			49.03		
7. Spanish Fines....	43.47		50.03	.16	
8. Spanish......	44.34		49.33	.08..	Copper .36 Barium 1.01 Selenium .15
9. Port Au Port, Nfld	45.57	1.42	51.63	None	
10. do do	44.76	2.04	50.04	None..	Copper, none
11. Hunting Island, Gulf St. Lawrence.....	42.39	2.37	48.55	Trace..	Copper, none Nickel, trace
12. Pyrrhotite Sudbury....	61.06		36.03	Trace..	Copper, trace Nickel 1.09

ANALYSIS OF CINDERS OR PURPLE ORE.

	Spanish.	Norwegian.	Average of German Practice.	Average of Spanish	Sydney Practice.
Fe.	*64.94	*57.00	**65.00	60.00	62.30
Mn.	0.02				Trace
SiO.	2.77	14.30	2.55	2.50	1.85
Al_2O_3.	0.26	3.00			1.00
CaO.	0.41				.10
MgO.	0.07				.43
Cu.	0.12	0.15	0.18		.30
Pb.	1.07	Trace	1.34		
Zn.	0.25	Trace	Trace		.52
CO.	Trace				.24
As.	0.03				
Sb.	0.04				
S.	0.47	0.17	0.36	0.75 to 1.75	1.47
Cl.	0.20	0.01	0.10		
Na.	0.10		from salt admixture		
P.	0.01			0.10	.015
BaO_2.					1.29

*Wedding. **Mostly from Spanish Pyrites.

Another use to which purple ore is put is in the manufacture of pigments. The ore, after it is taken from the furnaces where, in this case, it is not allowed to become any hotter than is absolutely necessary for the burning off of sulphur, is ground to a coarse powder. It is then put into retorts and heated to certain temperatures. According to the degree of temperature, the color of the ore is changed. Hence, any color from a light red to a dark red can be obtained by merely regulating the temperature to which the ore is heated. It is then ground to a very fine powder, thoroughly washed and floated, thus extracting from it any grit which may be present. The fine powder thus washed is separated according to the different degrees of fineness, and is sold sometimes in the pure state, other times mixed with anilines or other coloring matter. This sells from ½c. to sometimes 6c. per pound. It is largely used in the manufacture of paper, especially the so-called " Express " paper where a red color is required. The powder is mixed with the pulp in the beating engine and is retained in the pulp when this goes over the paper machine by the presence of the sizing agents which are mixed in with the pulp. Thus, when the paper comes off the machine, manufactured, it will have any color from a light red to a dark red depending upon the amount and kind of pigment used. It is also used as adulterants in paints, etc.

A Few Suggestions on Mineral Statistics.

By EUGENE COSTE, M.E., Toronto.

Before offering the following suggestions on "Mineral Statistics" I suppose I have first to plead guilty for the introduction (in the two first statistical reports of our Geological Survey, in 1886 and 1887) of the very system, or rather want of system, which I am now about to criticise, as I have felt for some time that it could be much improved to the great advantage of our mining and metallurgical industries. Being human we are, of course, all liable to errors, even in our best efforts, but false pride should never prevent us from endeavoring to rectify and improve, even if in so doing, we have to acknowledge mistakes of the past. Acting on this principle I am willing to do my best towards this rectification, but it can only now, on my part, take the form of suggestions, since I have long ago resigned my former position of Mining Engineer of the Geological Survey.

Clearness is the essential point of all good statistics; it is even paramount to absolute accuracy which often cannot be obtained, especially in this case of voluntary mineral statistics collected by the Geological Survey, or even when collected with more power of law, by our Provincial Mining Bureaus. But no matter how accurate statistics may be they will lose most of their value if they do not deal in the same tables with clearly defined units of the same class and character. If, for instance, we add in a statistical table the value of pulp wood with the value of paper it is quite certain that we obtain a sum which really means nothing, as it neither represents the pulpwood nor the paper production.

Have we not the same meaningless result when, in a statistical table, we add finished products, like fine copper or nickel, with such raw materials as iron ore, coal, petroleum or natural gas, and also with such other furnace or manufactured products as pig iron, matte, steel, coke, illuminating oil, brick, cement, carbide of calcium. &c.? Evidently yes! Such a table as the above gives us a total which cannot possibly mean anything, as it represents neither the production of our mines, nor the production of our smelting or other metallurgical works, nor the production of other manufactured products largely made up of minerals. The tables may be entitled "mineral production of Canada," or of Ontario, or of some other province, for such and such year, but in reality they are nothing of the kind and are simply additions of figures. It is indeed quite certain that fine nickel, or copper, are not ores or minerals any more than pig iron, matte, steel, coke, brick, cement, tile, sewer pipe, &c. When therefore we state, for instance, that in 1900 the mineral production of Canada was sixty-four and a half millions ($64,500,000) or that the mineral production of Ontario, in 1901, was $11,800,000.00, we really make statements that are far from being accurate, in there true sense. In reality the mineral production of Canada, or of Ontario, was less in the years above named. But, what is much worse than somewhat exaggerated values, is that it is impossible to tell, from the tables, how much these mineral productions really were; and thus, we are left entirely in the dark by the very statistics, collected and compiled with so much care and expense, to give us the very information which finally is missing. For indeed, if we try to get at the true mineral production, by deducting from the tables the values of the fine metals, mattes, pig iron, steel, brick, cement, lime and all other manufactured products, and by replacing these with the values of the corresponding raw materials at the mines or quarries, we cannot find these last, except in the case of iron ore, and thus, as we said above, we cannot arrive at the real value of the mineral production which is the very aim of all our efforts. The value of our mineral statistics, as now published, is therefore greatly lessened by the want of clearness in grouping so many classes of products (from the mine, the smelter, the brick yard, the cement mill, &c.) all into the one table. This system we submit should be done away with and replaced by the following:—

1st. Separate statistics of the first marketable products of our mines and quarries—spot values.

2nd. Separate statistics of the products of our smelting and metallurgical works—spot values.

3rd. Separate statistics of the products of other mills or works using ores or mineral as raw materials, such as petroleum refineries, cement mills, brick yards, lime kilns, &c.—spot values.

This is the system which has been followed for a great many years by most of the European countries, and it certainly presents, as we pointed out above, over the one now followed by us in Canada and by the United States Geological Survey, the advantages of: First, perfect clearness. Secondly, this system will also eliminate all fanciful values of fine metals, at New York, or other markets. These market values might very well be considered and given as a matter of valuable information in a statistical report, but should never, in our opinion, form the basis of values in the tables, as the spot values at the mines or works, are certainly the vital points required to be brought out since they constitute the actual facts which alone can be recorded and which alone are really useful as representing existing conditions. Thirdly, it is a much more elastic system as under it the values of the raw products of the mines and quarries are first given, then the values of the more of less finished products of the smelting and other works are given in other tables, so that there need not be any more fear of repetition of values as in the present tables; and, the statistical analysis of the different industries: mining, metallurgical, and allied industries can be pushed as far as desired, or convenient, or as far as it is possible to collect it.

Notes on the Geology of the Northern Portion of the Boisdale Hills Anticline.

By SHERMAN H BORIGHT, McGill University.*

The Boisdale hills are situated in Cape Breton Island. They extend from about longitude 60° 20′ 30″ west and latitude 46° 13′ north in a general direction, south 30° west to longitude 60° 40′ west and latitude 45° 58′ north.

The area of which this paper treats, embraces about four and one half (4½) miles of the northern portion of the hills, taking in the country on the west as far as the shore of Little Bras d'Or Lake, and, including also Long Island.

On the east, it extends to Jessop's Point and from there, parallel with the hills, as far south as the southern extremity of Long Island.

The geographical portion of the map accompanying the paper is taken from that published by the Geological Survey of Canada in 1899.

The geological boundaries, &c., have been put in from data collected while with the McGill Mining School, which under the guidance of Mr. O. E. LeRoy, B.A., made a study of this section in May, 1902.

Two main sections have been prepared,—one from Young's Point on St. Andrew channel across the Boisdale hills in a direction south 43° east, the other running east across Long Island about ¾ of a mile from its southern point, and meeting the first section at a point about one mile south east of Scotch Lake.

These sections show the relation of the various carboniferous and and metamorphic basins to the older underlying felsites, syenites, granites, &c.

The Boisdale hills form one of four parallel ridges, the Coxheath, Boisdale, Boularderie and St. Ann hills. These ranges of hills run in a direction from southwest to northeast and between them are deep valleys and indentations of the sea.

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*Awarded cash prize of $25.00 by Council for contribution to Student's Competition, 1903.

The general elevation of the Coxheath and Boularderie ranges is low. They seldom attain a height of over four hundred (400) feet, while the Boisdale hills rise, in places, to an elevation of eight hundred and ninety (890) feet, and the St. Ann hills to ten hundred and forty five (1045) feet.

At the northern end, the Boisdale hills slope down to sea level, from which they rise, gradually for about a mile and a half (1½) when the reach a height of six hundred and ninety (690) feet. For three (3) miles from this point, they have a more of less smooth top, ranging in elevation from six hundred and fifty (650) feet to seven hundred (700) feet.

Brooks and creeks are quite numerous, their general direction being parallel with the direction of the hills. On the west there are three creeks, Young's Creek whose course is in a general north-easternly direction, and two others running in a south-westernly direction, into the channel, near the southern end of Long Island.

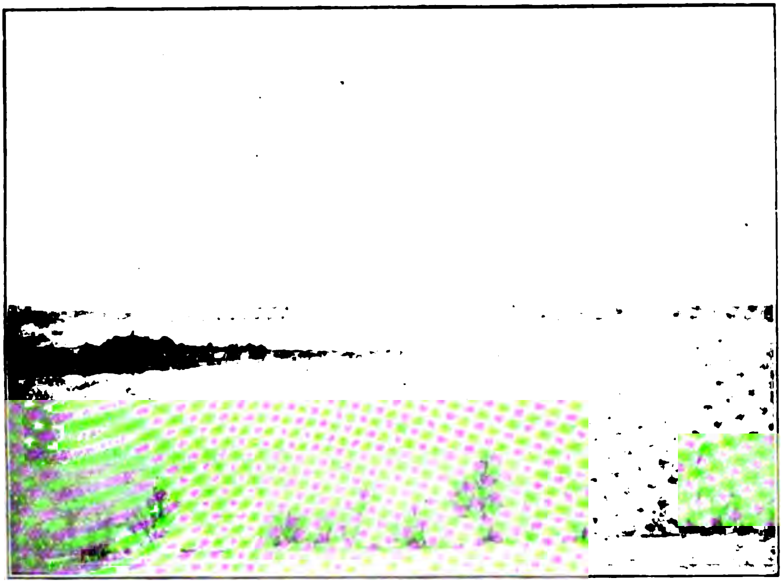
The total drainage of the eastern slope is carried off by the George River, which is only a small brook at its upper end, but which widens out, about two miles from its mouth, to nearly two hundred (200) feet in width.

For the last two (2) miles of its course, it has scarcely any current and is, in reality, an arm of the channel.

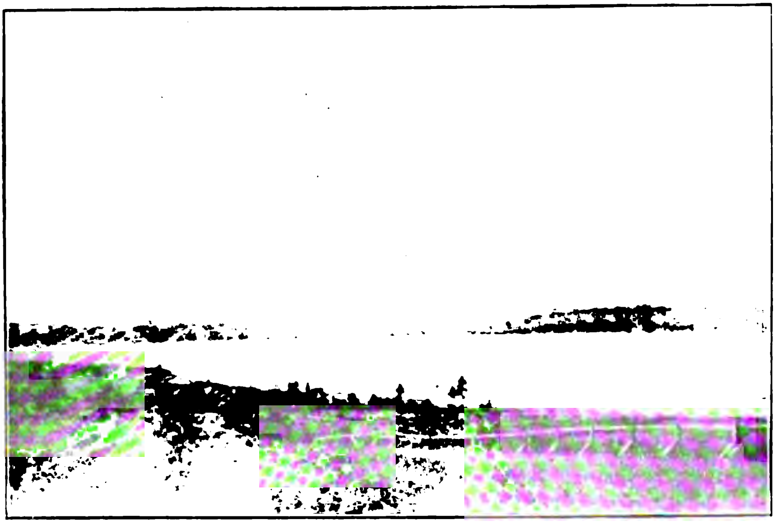
To the east of George River, the ground rises quite sharply to a height of one hundred and fifty (150) feet, when it becomes nearly level, sloping slightly to the northeast. This area is for the most part wet and swampy and is drained entirely by the outlet of Scotch Lake.

Most of the streams are mountain torrents running in fairly deep, stony ravines. In May, 1902, many of the smaller streams, on the eastern slope of the hills, were quite dry, although an exceptional amount of rain had fallen during the early part of the season. The streams on the western side run more or less along the side of the hill, while the tributaries of George River run, almost directly, down the hill side at an angle of from thirty (30) to fifty (50) degrees which accounts for their drying up so quickly after a rainy season

The land is, for the most part, rough and hilly with ledges of rock



Moore's Point—Photos showing the two Peneplains.



appearing above the surface almost everywhere. There are one or two fair farms along the northern slope of the hills from the northern end of Long Island to Moore's Point. On the east of the hills, the ground is too swampy for farming, although the land is very good, when properly drained

The central axis of the main anticline is composed, chiefly, of syentic and feldspathic rocks, flanked by Cambrian and Carboniferous strata. Denudation has been so great, however, that the carboniferous strata are now found in the valleys only, having been entirely worn away from the sides of the hills.

The main syenitic core is very regular in shape though it widens out slightly towards the lower end.

It is cut through, near Murphy Brook, by a dyke of highly metamorphosed diabase about ten (10) feet wide and one hundred (100) feet long, having a dip of 75°.

It contains small transverse veins of drusy quartz, irregularly distributed through it, and penetrating into the syenitic core on either side. These quartz veins are from one eighth (⅛) to one (1) inch thick and, in the syenite are perfectly barren, but in the diabase, are found to contain chalcopyrite—altered on surface to malachite—iron pyrites, galena, etc.

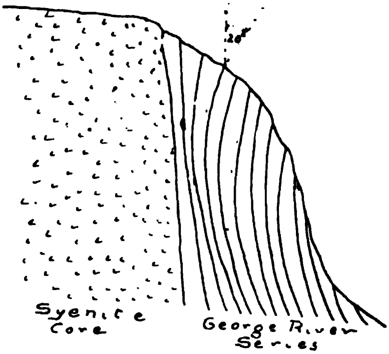
At the northern end of the axis we find granite intrusive in a small lenticular area of felsite. This felsite has dip of 70° west and strikes north 45° east at George River station post office.

On the northern end of the western flank is a strip of felsite about one quarter (¼) of a mile wide at its end and running out to a point about a mile and a-half from the northern end of the syenitic core.

On the east slope no Pre-Cambrian rocks are seen flanking the syenitic core north of George River. South of this, however, is a narrow zone of rocks from one quarter to one half mile wide consisting of highly crystalline limestone and dolomite interstratified with felsites. These rocks also contain tremolite, serpentine, pyrite and magnetite occurring in well formed octahedra and in streaks and patches.

This formation, known as the George River limestone series, flanks the plutonic core from this point on to the south.

Both the felsites on the west, and the George River series on the east, are tilted at a very high angle, never less than 70° and in some places, especially near the contact of the dolomite and syenite, the folding has been so great that the George River series dips towards the hill at angle of 80°.



On the west side of the Pre-Cambrian axis, we have the Cambrian represented by the barachois slates and other rocks belonging to the horizon of the Lingula Flags series. They comprise reddish, greenish, bluish and gray slate, quartzite, sandstone, etc. And in them are found specimens of Acrothele,—a brachiopod of lower Cambrian—and also a specimen of Lingula.

These Cambrian rocks are very highly crumpled towards the northern end of the anticline giving rise to many very well developed anticlinal and synclinal folds.

The Cambrian rocks dips away from the Pre-Cambrian axis at an angle varying from 5° at the northern end to 85° near the southern end of Long Island. Along the shore of St. Andrew Channel, they dip inland, forming a synclinal fold whose centre runs nearly parallel to the Pre-Cambrian axis and about half a mile from it.

At the northern extremity of the felsite, on the west side, is a small lozenge shaped patch of the Cambrian slates which has, so far, escaped denudation and still remains on the slope of the anticline.

The Cambrian rocks extend under the channel except at Young's

Point where we have a small exposure of the Carboniferous limestone which lies unconformably on the highly crumpled slates. At this point, strike of slate and limestone is north 55° east. Dip of slate 60° to south east. Dip of limestone 30° to North West.

The limestone here is very fossiliferous and is weathered to such an extent that good specimens are easily obtained. Specimens of Conularia, Productus and Terebratula were obtained here.

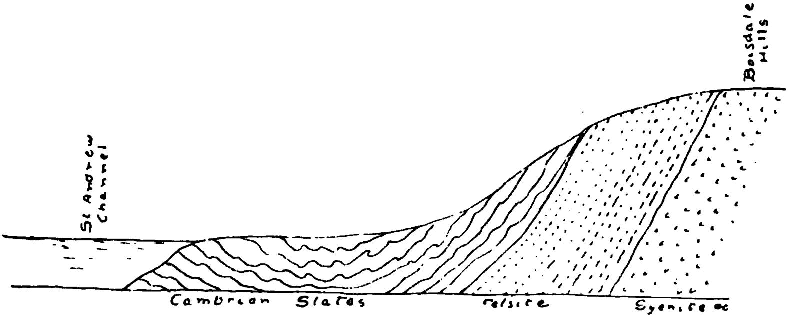
The Carboniferous limestone also appears on Mouse Island and, directly across St. Andrew channel at Shawfield Point, on Boularderie Island.

Long Island—From I.C.R.

On the eastern slope, the Cambrian is wanting and the Carboniferous limestone lies directly on the Pre-Cambrian axis. These rocks here consist entirely of limestone, laminated and compact and generally, dark grey in color. At Moore's Point, a small lamina of light grey limestone appears. In other parts, this series generally consists of thick beds of argillaceous shales, &c., associated with the limestone, but here, the shales seem to be entirely wanting.

The bedding is even and the dip is regular, increasing in sharpness as we go farther south. At George Pond, where the Carboniferous limestone meets the George River series, the dip of the former is from 40° to 60°.

The rocks overlying the Carboniferous limestone series are well exposed and occupy a position analogous to that of the millstone grit of the English coal fields. They consist of a series of sandstone beds, generally coarse and often almost conglomerate in character, containing a large number of fragmentary fossils, such as Sigilaria, Stigmaria, Sepidodendron, Calamites, &c.

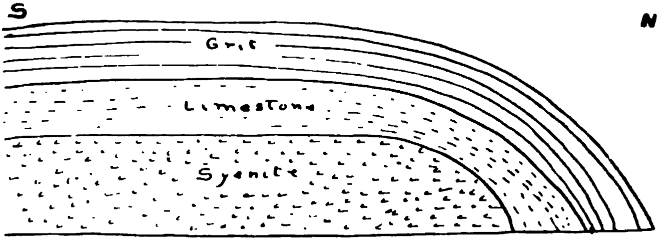


Section from St Andrew Channel to Boisdale Hills

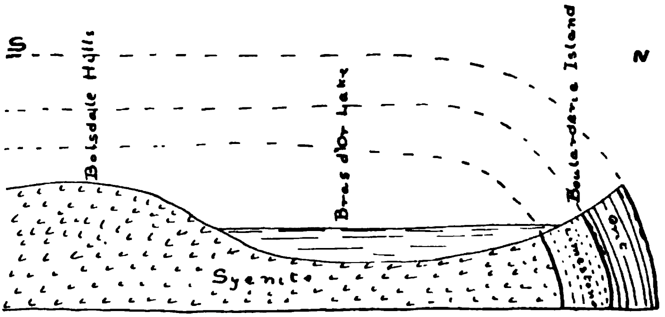
There can be no doubt but that the grit in this locality is made from the disintegration of the underlying rocks, probably of the older crystalline rocks, as some of the beds of the millstone grit are found to be largely composed of fragments of felsite, similar to that found in the Boisdale hills.

The millstone grit dips at an angle of about 30° in an easterly direction at the upper end of the anticline, but, about three (3) miles south, it begins to dip towards the north, forming a saucer shaped basin, the rim of which is formed by the Carboniferous limestone.

We see from the above that the Pre-Cambrian axis was, at one time, covered by the carboniferous formations which have since been worn away, leaving the Pre-Cambrian core bare. The following sketch sections will give an idea of the anticline as it was laid down, and as it is now.

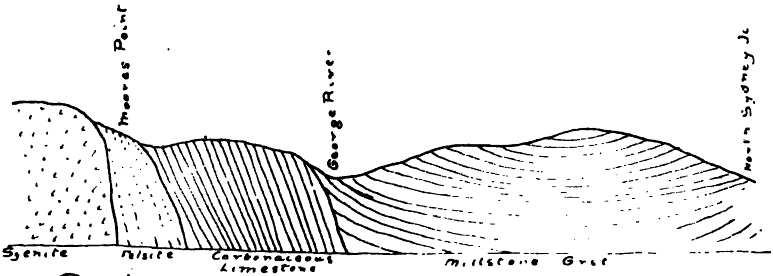


North and South section throug. anticline as originally laid down



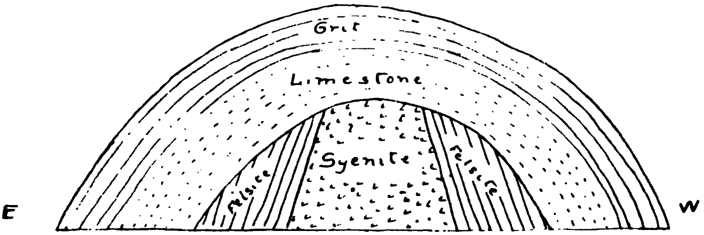
Same section after erosion.

16.

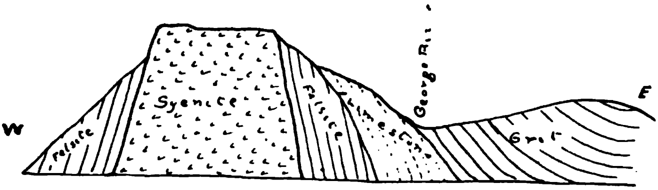


Section from Moore's Point to

North Sydney Junction.



East and West section before erosion showing the Carboniferous strata lying uncomformably on the Pre-Cambrian axis

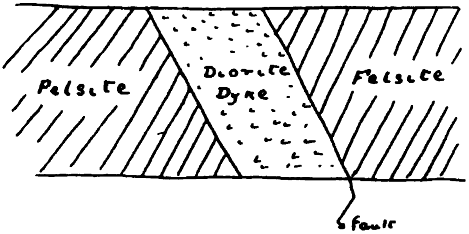


Same section after erosion

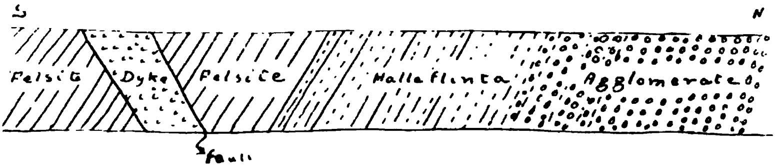
SUBORDINATE PRE-CAMBRIAN AXIS OF LONG ISLAND.

On Long Island, we have a subordinate Pre-Cambrian axis of felsite, running across the island at an angle, and nearly parallel with the Boisdale hills.

It is evidently part of an anticline similar to that of the hills on the mainland but much smaller. The felsites are tilted at a very high angle and slope towards the mainland. Through them, and at right angles to the axis, run igneous dykes. Those that we examined consisted of diorite, bearing garnet disseminated through it.



Section through dyke on Long Island



North and South secton through Long Island

At the northern end of the island, we have the felsites intermixed with sandstones, and still farther on towards the end, they pass into an agglomerate.

On the east of the Pre-Cambrian axis we have a small area of sandstone and conglomerate. The sandstone has many small, irregular quartz veins running through it. In it were found a few good specimens of lingula. These sandstones are evidently older than the Cambrian slates of the mainland, although still belonging to the Cambrian.

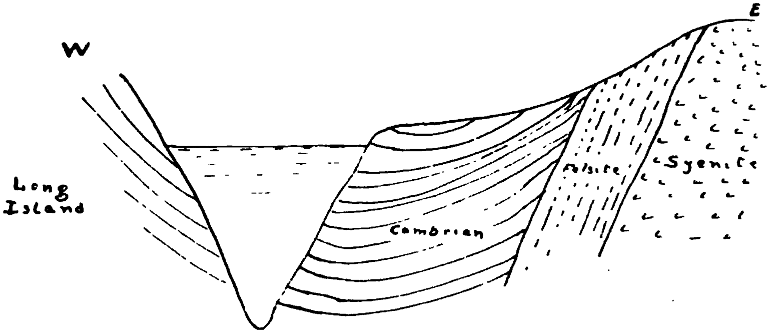
On the west we have a small area of carboniferous limestone. This is tilted at a very high angle, in fact, so much so, that it lies partially under the older felsites.

Granitic and Syenitic Rocks.—The rocks of the central core are almost entirely quartz-syenites. The feldspar is flesh colored in all cases and the quartz, milky. On much weathered surface, the color is almost white, on slightly weathered surface, it is pinkish brown, and on fresh surface, it is a light pink or flesh color. The hornblende, on weathered surface, is entirely altered to chlorite, but towards the centre of the mass, hornblende is present in small particles quite widely scattered.

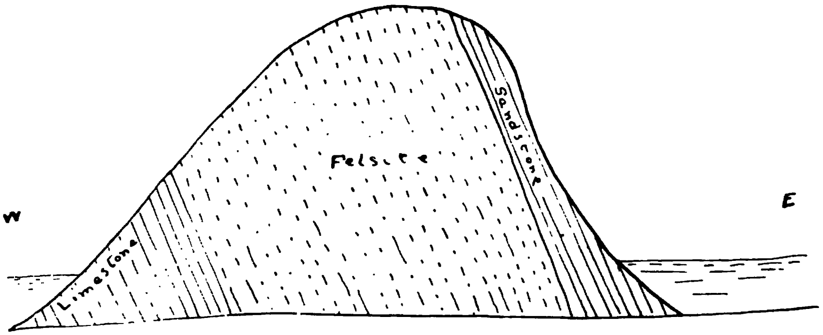
Long Island—From I.C R.

A specimen taken from the north end of the hills is almost entirely made up of feldspar and quartz, there being but a few spots of chlorite to show where a little hornblende or mica had been. In the best specimen obtained, very little mica could be found and still a little chlorite.

Felsite.—The felsites, both of Long Island and the mainland, are fine grained, in color, greenish, grey, or dark reddish brown. The reddish variety is covered on the surface with a thin layer of hematite which gives the rock a greasy feeling and causes it to soil the hands. The freshly fractured surface or the reddish variety will give the red streak of hematite.



Section showing relation of Cambrian of Long Island to Cambrian of mainland



East and West section through Long Island

Both varieties seem to be composed principally of feldspar. If quartz is present it is in very fine particles and intimately mixed with the feldspar. In the greenish variety, small crystals of feldspar can be seen scattered through the mass, but the red felsite seems to be of a more uniform structure and finer grained than the green, although both occur in the same beds and very close to one another. Both break up into rough rhombohedra, very similar in appearance to the Belle Isle iron ore.

George River—From I C.R. Bridge.

These felsites probably resulted from the compacting of volcanic ashes thrown out in Laurentian or Huronian times.

Dolomite.—The dolomite of the George River limestone series occurs in a bed one hundred and forty four (144) feet thick and is both coarsely and finely crystalline.

In this vicinity, the greater part of it, however, is of the fine grained variety. Both kinds are nearly pure white except where colored by impurities. With the dolomite are associated pyrite, tremolite, serpentine, etc.

The serpentine occurs interbanded with the dolomite, with small veins of dolomite running through it. It is a light yellowish green in color and has a somewhat waxy appearance.

The tremolite is found in veins or streaks through the dolomite. On the weathered surface it has much the same appearance as the dolomite, both being a light grey. The freshly fractured surface is, however, very different. It has a silky appearance very similar to asbestos, and is quite transparent on its thin edges. The fibres run in no fixed direction, but in some parts lie nearly at right angles to their direction in other parts. In some specimens it is very nearly asbestos.

Pyrite.—The pyrite occurs in a massive state in streaks and pockets in the dolomite, with the dolomite disseminated through it, though, in some parts, the dolomite can scarcely be seen.

The pyrite is easily seen by the quarrymen as it darkens the dolomite around it for a considerable distance. It therefore shows up very plainly against the white back ground of pure dolomite.

A small quantity of magnetite was found in a prospecting pit in the dolomite. It occurred principally in streaks and in masses consisting of small but well formed octahedra.

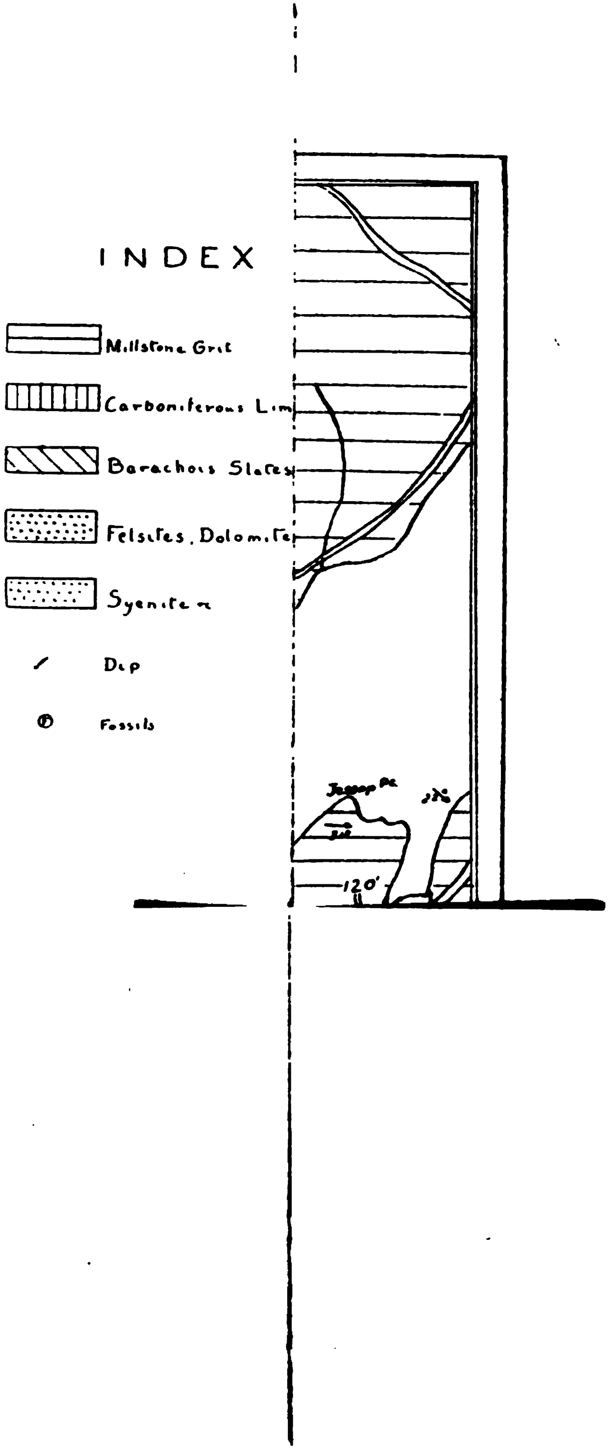
Veins and pockets of pure calcite are also found in small quantities and also some very small veins of asbestos.

Cambrian Slates and Quartzites.—Near the hills, we find the shales and quartzites interbanded with igneous sills, rich in iron; farther out, however, we have the quartzites becoming more massive but passing up into shales as before. The quarzites are very finely bedded and are greenish in color. The shales are of a reddish color due to the iron, and they break up very readily.

Near the mouth of Young's Creek the sandstones are argillaceous and occur, with a slaty cleavage, in beds about fifteen (15) inches thick.

The movement that produced the folding and sliding also produced parting planes at right angles to the bedding planes.

About half way between Youngs Creek and Youngs Point, we find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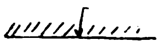
the shales inter-stratified with a white quartzite containing much chlorite.

Near the hills, the movement has been so great that nearly every fragment of sandstone will show excellent slickenside surfaces. The fragments generally have a very thin edge as though it had been pinched out from between two other strata. In figures arrows represent direction of the pressure.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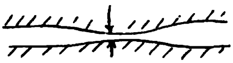
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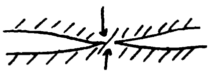
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On Long Island the Cambrian rocks present the appearance of true sandstones and conglomerates. The sandstone is here rather coarse but it is evenly bedded, having small veins of drusy quartz running through it. The pebbles in the conglomerate seem to be feldspar altered to kaolin on the surface. These sandstones underlie the slates and quartzites of the mainland.

On the mainland, opposite the lower end of Long Island, the Cambrian rocks show evidence of great pressure, as they are schistose in structure. The slates have here been very nearly turned into a mica schist, the mica being sericite, a variety of muscovite.

Very few fossils were found in the Cambrian rocks. A few specimens of lingulae were seen on Long Island and near Young's Point. At the latter place, was also found acrothele, a species of Lower Cambrian brachiopod.

The lingulae found on the mainland are slightly broader than long, and very thin, while those on Long Island are about the same length as width, but with a considerable thickness, both being about one half (½) inch in length.

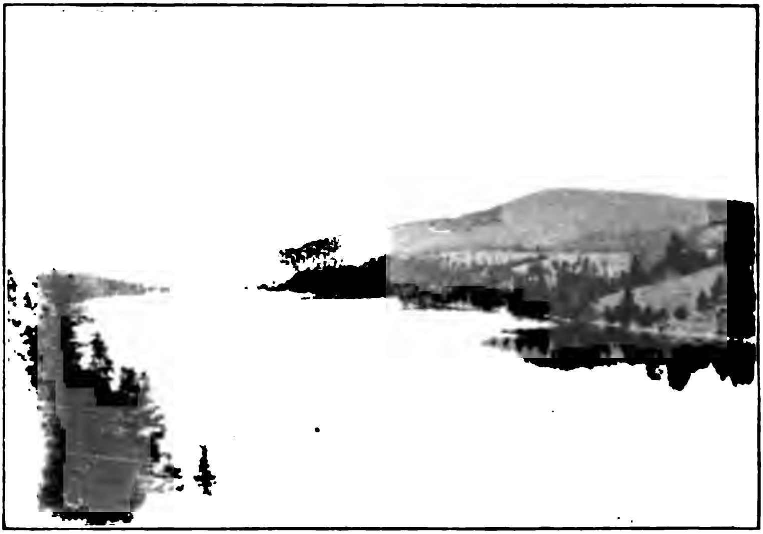
Acrothele very much resembles a slightly flattened sphere about one half (½) inch in diameter.

Carboniferous Limestone.—The carboniferous limestone, on both east and west sides of the anticline, consists of bituminous limestone interstratified with ordinary light colored limestone. The beds are from four to ten inches thick with parting, usually of shaly bands but, in some cases, nodular.

At Moore's Point we found crinoid stems, cyathophyllum, productus, etc., while specimens of productus, terebratula, conularia and orthoceras were seen at Youngs Point.

Cyathophyllum is a species of rugose coral with a circular cross-section ; it is quite short and curved at the base.

The calice is shallow with about forty equal straight septa while the surface has vertical ribs and strong transverse plates. All specimens found were small, the largest being hardly one half (½) inch in diameter.



Scotch Lake.

Productus.—Specimen is one and one eighth (1⅛) inches along the hinge line and one (1) inch long. The surface is covered with longitudinal, nearly straight, thread-like striae with interspaces of slightly greater width. The ribs are closely crossed by small concentric lines.

Terebratula.—This species of brachiopod was found in great abundance at Youngs Point. The specimens were all small, the largest being about five-eighth (5/8) inches long and the smallest, not over one quarter (1/4) of an inch long. The ventral value is uniformally convex, in nearly all specimens, in one, however, it is slightly depressed near the front.

Typical photo of the country underlain by Cambrian.

Conularia.—A species of Pteropoda. Form very elongate and pyramidal, with rhombic cross-section; cross-section was probably square originally but has been made rhombic by pressure, The surface is marked by felspathic fragments from the hills near by. It is, as a rule, coarse, and in places is conglomerate in character and deeply stained on surface with peroxide of iron. Some beds are evenly grained and flaggy with patches of argillaceous shale and thin coal seams. It contains a great number of fragmentary fossils of calamites, stigmaria, sigillaria and lepidodendron.

Calamites.—Specimen is about two inches wide and six inches long and consists of flattened out cylindrical stem, regularly marked with longitudinal striae or furrows and cross joints. The back still remains in patches by thin, raised ribs forming an angle of about 120° in the middle line of each face. Breadth of specimen ⅜ inches and its length 1¾ inches.

Typical photo of the country underlain by Cambrian.

Orthoceras :—A species of cephalopod. Specimen is about two inches long and one half inch in diameter. Shell is long and conical with nearly circular cross section. Shell is divided by septa which are distant from one another by about half the diameter of the shell. At end of shell is a small nearly central siphuncle.

Millstone Grit.—The Millstone grit is here an orcose sandstone containing feldspar and is made up principally of the syenitic and feldspathic patches in form of coal. The other fossils obtained were so fragmentary that they could scarcely be recognized.

ECONOMIC GEOLOGY.

Granites and Syenites.—The granites and syenites of the Pre-Cambrian axis are, for the most part, situated at distances varying from a

Dolomite Quarry.

few yards to a mile from the line of the Intercolonial Railway and could be easily utilized for both monumental and building purposes. These rocks have a fine variety of different shades of color and take a very high polish, fit for decorative work. A small amount of this rock has been quarried by the Intercolonial Railway, for use, in filling in embankments. At the point where they got it out, it was transferred to the side of the railway line by means of chutes.

Dolomite Quarry.

Copper.—The felspathic rocks of the Boisdale hills contain a considerable amount of chalcopyrite. One vein, twenty (20) feet wide, is situated on the hills about half a mile from the Intercolonial Railway.

This vein has been developed to a considerable extent but has not been worked for some time. Similar deposits are found in the Coxheath hills and trial shipments have been made to Boston, Mass., where the ore was smelted and is reported to have given satisfactory results.

Dolomite.—The dolomite bed of the east of the hills is now quarried by the Dominion Iron and Steel Company for use as a flux in their blast furnaces at Sydney, C.B. It is reported to be satisfactory in every respect when proper care is taken to get rid of the pyrite and serpentine.

The serpentine is found, when crushed, to make excellent material for roads, as it packs very firmly in a short time and does not pack so tightly as to prevent good drainage. At the Sydney steel works, it is used with a foundation of broken slag and makes a road nearly as smooth as asphalt and much better for horses feet.

The rock is quarried by blasting from the bottom and thus undermining the top.

ANALYSIS OF DOLOMITE.

An analysis by Dr. Hoffman, is as follows :—

Carbonate of lime	53.018
Carbonate of magnesia	43.583
Carbonate of iron	.506
Carbonate of manganese	.266
Sulphate of lime	1.771
Chlorine	.036
Water { **hydroscopic**	.272
Water { combined	.071
Insoluble residue	1.553
	101.076

An analysis given by the Dominion Iron and Steel Co., is as follows :—

Silica	.980
Iron per-oxide	.300
Alumina	.370
Carbonate of lime	56.320
Carbonate of magnesia	41.600
Sulphur	.030
	99.600

Lime.—The limestone of the Carboniferous series produces, when calcined, a good strong lime, but is rather dark for the interior finishing of houses. An unlimited supply can be produced at a very low cost as beds of considerable thickness crop out very near the Intercolonial railway. Lime has been burnt near George River, at George Pond, and a considerable amount was exported. None is being burnt at present, however.

Marble.—In the same series with the dolomites, white and variously tinted marbles can be very easily obtained and have, formerly, been quarried here to a considerable extent.

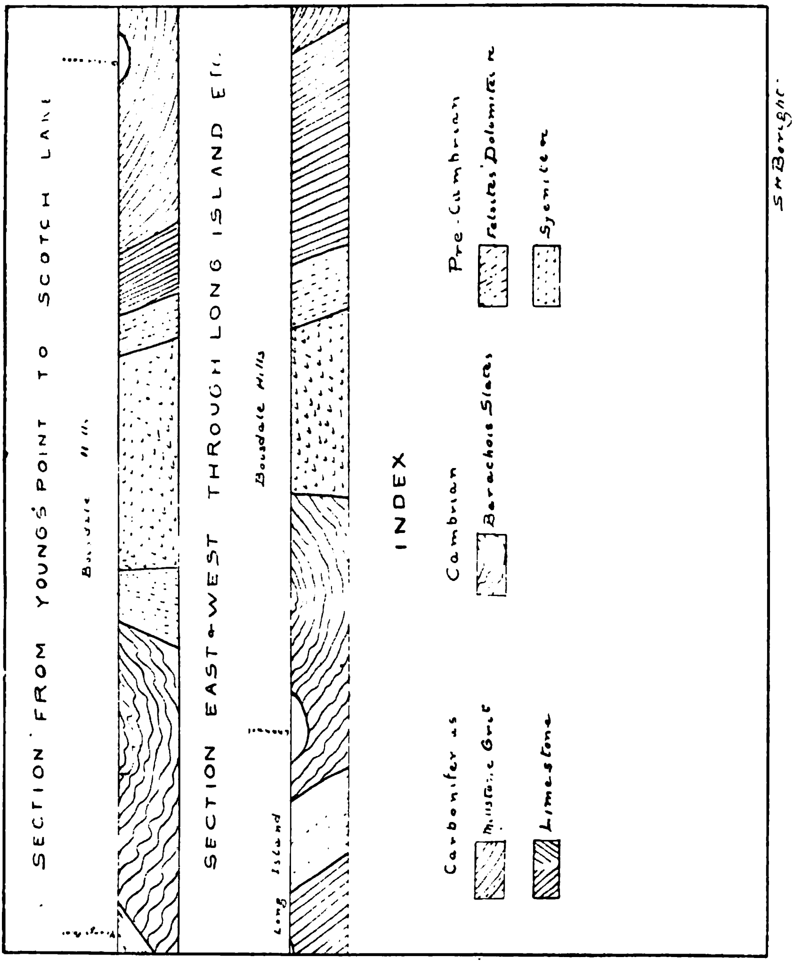
Grit for Grindstones, etc.—The sandstone of the millstone grit is as a rule, too coarse and too irregular in bedding and, also, too much impregnated with iron to yield good building stone, except for foundations and rough work. Some of the beds have produced excellent flags, which have been quarried to a small extent, for local use. In this region the sandstones are altogether too uneven for use in the manufacture of grindstones, etc.

Iron.—Some very good specimens of hematite were shown us on Long Island but we could not find the pit from which they were taken. Since then the mining rights for Long Island and a part of the Boisdale Hills have been sold for $100,000 and iron is said to be the chief ore to be mined.

When from these facts and other data, we begin to consider the position this region occupies in geological time we find that the oldest sedimentary rocks belong to the Paleozoic period. It is represented, in the first place, by the Cambrian system, which appears as Barrachois slates.

At the beginning of the Carboniferous we find the eastern border basin broken up into a series of ridges and hollows. This was caused by a great uplift which took place at the close of the Devonian and extended along the Appalachian axis. All the sedentary rocks, from Cambrian to Devonian inclusive, were affected by movement and mountains 10,000 or 15,000 feet high were formed. Filling in the broad basins between these upturned rocks we find the Carboniferous, the last of the Paleozoic systems represented here.

At the close of the Triassic during which sediment was deposited in the Bay of Fundy, and the Gulf of St. Lawrence, a further uplift took place.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Then we have an example of the work of the agents of erosion, the rivers, etc., for or at about the close of the Cretaceous the whole land was reduced almost to sea level.

The Tertiary was characterized by almost the same movements, that is, a broad uplift at the beginning and then the work of erosion went on until a second pene plain was formed, underlain by carboniferous and triassic rocks. The higher ridges in this plain are the remains of the first pene plain.

The land was again uplifted in pre-glacial times and deep valleys carved out. Post-glacial times brought a depression and, in consequence of this, the rivers are all tidal inlets having been drowned at their mouths.

This post-glacial depression also accounts for the very irregular coast line of the eastern Border Basin.

MEETINGS.

SUMMER MEETING

NELSON, B.C.

10TH, 12TH SEPTEMBER, 1902.

A meeting of the British Columbia members was held in the Board of Trade, Nelson, British Columbia, on Wednesday and Friday, 10th and 12th September, 1902. The following signed the register of attendance :—

J. H. Tonkin, General Manager, Crow's Nest Pass Coal Co., Fernie.
J. H. MacKenzie, E.M., General Manager, Le Roi Mining Co., Rossland.
Bernard MacDonald, E.M., General Manager, Rossland Great Western, Rossland.
S. S. Sorensen, M.E., Velvet Mines, Ltd., Rossland.
Wm. Thompson, Superintendent, Le Roi No 11, Rossland.
S. S. Fowler, S.B., E.M., London and B.C. Gold Fields, Nelson.
Leslie Hill. C. and M.E,, Hastings (B.C.) Exploration Co., Nelson.
R. R. Hedley, Hall Mines, Ltd., Nelson.
James Cronin, St. Eugene Cons. M. Co., Moyie.
James McEvoy, Crow's Nest Pass Coal Co., Fernie.
Frank Fletcher, P.L.S., Nelson.
James W. Moffatt, B.Sc., Nelson.
Norman Carmichael, Assayer, Nelson.
Ernest Woakes, M.E., Duncan United Mines, Nelson.
A. C. Garde, E.M., Payne Consolidated, Sandon.
S. F. Parrish, E.M., B.C. Chartered Co., Eholt, B.C.
H. E. C. Croasdaile, Nelson, B.C.
Alex. Sharp, Mine Superintendent, Rossland.
H. Mortimer Lamb, Editor B.C. Mining Record, Victoria.
E. B. Kirby, E.M., General Manager, Centre Star Mining Co., Rossland.
Bruce White, Molly Gibson M. Co., Nelson.
M. H. Davys, C. & M.E., Nelson, B.C.
A. H. Gracey, Venus and Athabasca Mines, Nelson, B.C.
G. W. Chaplin, St. Catherines, Ont.
E. E D. Wilson, Kingston, Ont.
Smith L. Curtis, M.L.A., Rossland, B.C.
H. C. Black, Nelson, B.C.
B. T. A. Bell, Editor *Canadian Mining Review*, Ottawa.

The opening session was held on Wednesday afternoon, 10th September, at three o'clock.

On motion of the Secretary, Mr. S. S. Fowler, E.M., was called to the chair.

Mr. S. S. FOWLER, in welcoming the members of the Institute to Nelson, referred to the excellent work done by the organization on behalf of the profession and industry of mining in Canada. The proposition to organize a local branch in the Province was one which received his heartiest commendation, and would doubtless be carried out. The following new members were elected.

NEW MEMBERS.

Dr. Bernard Mohr, Mond Nickel Co., London, Eng.
Mr. Wm. Thompson, Superintendent, Le Roi No. 11, Rossland.
Mr. J. H. MacKenzie, E.M., Le Roi Mining Co., Rossland.
Mr. S. S. Sorensen, M.E., Velvet Mine, Ltd., Rossland.
Mr. J. H. Tonkin, General Manager, Crow's Nest Pass Coal Co., Fernie.
Mr. Thomas Stockett, Jr., Superintendent, Crow's Nest Pass Coal Co., Fernie.
Mr. James Cronin, St. Eugene Con. Mining Co., Moyie.
Mr. George L. Griffith, C.E., Winnipeg.
Mr. Frank H. Probert, M.E., Los Angeles, Cal.
Mr. Edward H. Sanborn, Con. Lake Superior Co., Philadelphia.
Mr. A. R. Wilson, Crow's Nest Pass Coal Co., Fernie, B.C.
Mr. R. W. Coulthard, Analytical Chemist, C.N.P. Coal Co , Fernie, B.C.
Mr. H. C. Riehle, Mining Engineer, Black Lake, Que.
Mr. H. Mortimer Lamb, *B. C. Mining Record*, Victoria, B.C.
Mr. James W. Moffat, B. Sc , Nelson, B.C.
Mr. Norman Carmichael, Assayer, Nelson, B.C.
Mr. Frank Fletcher, P.L.S., Nelson, B.C.
Mr. A. H. Gracey, Athabasca-Venus Mines, Nelson, B.C.
Mr. Aaron H. Kelly, Nelson, B.C.

MINE SIGNALLING BY COMPRESSED AIR.

Mr. WM. THOMPSON, Superintendent of LeRoi No. 11, Mining Company, presented a paper on this subject, reproduced elsewhere in this volume.

TIMBERING BY THE SQUARE SETT SYSTEM AT ROSSLAND.

Mr. BERNARD MACDONALD, General Manager of the Rossland Great Western Mimes, Ltd., presented a summary of his paper, reproduced elsewhere in this volume, which provoked an interesting discussion among the members.

B. C. BRANCH ORGANIZED.

The SECRETARY explained that in accordance with a resolution passed at the last annual meeting. it had been determined to organize branches of the Institute in different sections of the Dominion, and two had already been formed in Ontario and Quebec. The Institute had a large and representative membership in British Columbia, and if this was organized into a Provincial Branch, meetings could be held at different provincial points more frequently, and doubtless much good could be accomplished for the profession and industry of mining in British Columbia.

Mr. BERNARD MACDONALD, (Rossland)—I am satisfied it will be a great advantage to have a Provincial Branch of the Institute in British Columbia to compare ideas on mining practice in the various districts of the Province, and also to promote better mining legislation.

Mr. E. B. KIRBY, (Rossland) concurred, and suggested that, inasmuch as many of the members of the Institute were also members of the British Columbia Mine Owners' Association, it would be advantageous to both if it could be arranged to hold their meetings at the same time and place. One meeting could be devoted to business and government questions and the other to the discussion of papers.

After some further discussion, a resolution—"That a branch of the Institute in British Columbia be now formed," was unanimously adopted. The appointment of a committee of management was deferred until a later session.

The meeting adjourned at 5.30 p.m.

WEDNESDAY EVENING SESSION.

The members reassembled at eight o'clock, Mr. Leslie Hill, C. & M.E., Nelson, being called to the chair.

COARSE CONCENTRATION IN THE SLOCAN DISTRICT.

Mr. S. S. FOWLER, S.B., E.M., presented his paper on Coarse Concentration in the Slocan District, B.C., reproduced elsewhere in this volume.

THE INFLUENCE OF GOVERNMENT UPON MINING.

Mr. E. B. KIRBY, presented his paper on the "Influence of Government upon Mining" reproduced elsewhere in this volume together with the subsequent discussion thereon. This question occupied the attention of the members until ten o'clock, when the meeting adjourned.

FRIDAY AFTERNOON SESSION.

The members assembled at three o'clock. Mr. Robert R. Hedley in the chair.

BRANCH EXECUTIVE APPOINTED.

On motion, the following executive of the British Columbia branch of the Institute was elected :—S. S. Fowler (chairman) and R. R. Hedley, Nelson ; E. B. Kirby and Bernard Macdonald, Rossland ; F. Keffer and S. F. Parrish, Boundary District ; James Cronin and A. C. Garde, Slocan ; J. H. Tonkin, Fernie ; W. F. Brewer and W. F. Robertson, Victoria.

FURTHER DISCUSSION OF MR. KIRBY'S PAPER.

The adjourned discussion in Mr. Kirby's paper on "The Influence of Government upon Mining" occupied the attention of the meeting for the greater portion of the session.

PAPERS READ BY TITLE.

The following papers were then read by title :—

On the Future of the Coal and Coke Supply of British Columbia.
By Mr. Wm. Blakemore.

On the Mineral Resources of Vancouver Island.
By Mr. W. M. Brewer, Vancouver.

On the Machinery Constituting a Mining Plant.
By Mr. A. C. Garde, Sandon.

EXHIBIT OF A MODEL OF THE POORMAN MINE.

The SECRETARY remarked that as Mr. Norman Carmichael, who had constructed the exceedingly interesting glass model of the Poorman Mine, which had been on exhibition in the hall during the meeting, was present, the members would be pleased if he would make a few remarks upon the model.

Mr. NORMAN CARMICHAEL—I appreciate very much the kind re-remarks that have been made regarding the model on exhibition and the interest taken in it by the members present. I must explain, however, that the model was not made with a view to public exhibition, and in many respects it is crude and unfinished. On it you will notice Eagle Creek flowing down the gorge, the profile of the hillsides, the outcrop of the vein, tunnels, stopes, dykes, faults, and nearly everything connected with the mine but the 2 per cent. tax. My attention was first drawn to the striking manner in which the workings of a mine can be shown on glass by the beautiful models in the museum of the Bureau of Mines in San Francisco, which are well worth a visit ; and later I was indebted to Mr. W. A. Carlyle, who was a strong believer in their usefulness, for some suggestions regarding plotting on glass, and also to Dr. James Douglas, of Bisbee, Arizona, who very kindly supplied me with notes on the construction of the large glass model of the Copper Queen Mine at that place. That mine models are of more than mere artistic value is shown by the extensive use made of them by the courts in Colorado, and elsewhere, to aid in the adjustment of many important mining disputes, and I have no doubt that were they more generally employed by mining engineers they would often prove an invaluable aid in the solving of difficult underground problems. In the present instance the model was constructed with a view to showing a rather intricate system of dykes and faults which traverse the vein in an irregular manner, the dykes varying in thickness from a fraction of an inch up to about 20 feet, and for the most part dipping in an opposite direction to the vein, while the faults have in most cases caused a displacement of only a foot or two, one of them throws the vein some 25 feet and thereby affected the workings considerably in the ground contiguous to it. These dykes and faults are shown in different colors so that they may be more clearly traced in their meanderings through the mine. The model is made to a scale of 40 feet to the inch, the block of ground represented being 1,200 feet long by 800 feet wide, and with a vertical depth of 560 feet. The strike of the vein is made approximately parallel to the longest dimension of the model, and each sheet of glass represents a transverse section through the vein and workings. The sections being placed at a uniform distance apart, corresponding to 50 feet in the mine, where important workings, such as upraises, fall between the regular sections, and in consequence would not be shown on them, intermediate sections are set up at their correct angles. All the sections are easily removed and replaced, so that the model may be kept up to date with the surveys in the mine. If there is any further explanation desired by any one I shall be very pleased to give it.

Mr. ERNEST R. WOAKES, managing engineer of the Duncan United Mines, desired to bear testimony to the care that had been taken in making the model as accurate as possible, and to the practical utility of the model in the actual working of the mine, and felt sure that were the practice of making these models more general much benefit would accrue.

NEXT MEETING OF THE BRANCH.

On motion it was decided to hold the next meeting of the Branch in Victoria some time in March, 1903. The meeting adjourned at 5.30 p.m.

ENTERTAINED BY THE CORPORATION.

On Thursday evening the members of the Institute were the guests of the mayor and corporation of Nelson at a banquet in the Hume House. About one hundred persons sat down to an excellent dinner. After the usual loyal and patriotic toasts, the mayor proposed the "Mineral Industries" in an excellent little speech. On behalf of the industry suitable responses were made by Mr. S. S. Fowler, Mr. B. T. A. Bell, and Mr. Bernard MacDonald. A splendid musical programme was presented and the festive gathering did not separate until daybreak was well advanced.

ANNUAL MEETINGS

MONTREAL.

4TH, 5TH, AND 6TH, MARCH, 1903.

The Annual General Meetings of the Institute were held as usual in the Club Room, Windsor Hotel, Montreal, on Wednesday, Thursday aud Friday, 4th, 5th and 6th March. The following among others signed the register of attendance :—

Thos. Cantley, Nova Scotia Steel and Coal Co., New Glasgow, N.S.
Robert E. Chambers, N. S. Steel and Coal Co., Wabana, Newfoundland.
B. A. C. Craig, Canada Corundum Co., Craigmount, Ont.
Major R. G. Leckie, International Nickel Co , Sudbury, Ont.
Captain J. Edwards Leckie, D.S.O., Torbrook Iron Mines, Torbrook, N.S.
Joseph Errington, Massey Station Mining Co., Massey, Ont.
Thomas W. Gibson, Director Bureau of Mines, Toronto.
George E. Drummond, Canada Iron Furnace Co., Montreal.
George R. Smith, M.L.A., Bell's Asbestos Co., Thetford Mines, Que.
Harry J. Williams, N.E. Can. Asbestos Co., Thetford Mines, Que.
James R. Pearson, Asbestos and Asbestic Co., Danville, Que.
Charles Fergie, Intercolonial Coal Co., Westville, N.S.
A. W. Robinson, C.E., Montreal.
W. G. Miller, Provincial Geologist, Toronto, Ont.
Dr. Robert Bell, Geological Survey, Ottawa.
E. D. Ingall, A.R.S.M., Chief Division of Mines, Geol. Survey, Ottawa.
A. P. Low, Geological Survey, Ottawa.
Russell Blackburn. Blackburn Mica Mine. Ottawa.
Prof. C. K. Leith, U.S. Geol. Survey, Madison, Wis.
John E. Hardman, S.B., M.E., Montreal.
Eugene Coste, E.M., Prov. Nat. Gas and Fuel Co., Toronto.
Thomas J. Drummond, Londonderry Iron Co., Montreal.
Prof. J. Bonsall Porter, McGill University, Montreal.
C. P. Hill, New York.
Fred. W. Hobart, Engineering and Mining Journal, New York.
J. E. Saucier, Matane Copper Co., Matane, Que.
J. Obalski, E.M., Inspector of Mines, Quebec.
Jules Cote, Sec. Dept. Lands, Fisheries and Mines, Quebec.
Dr. Frank D. Adams, McGill University, Montreal.

Dr. W. L. Goodwin, Director School of Mining, Kingston.
Dr. Eugene Haanel, Superintendent of Mines, Ottawa.
Dr. T. L. Walker, Toronto University, Toronto.
G. R. Mickle, M.E., School of Practical Science, Toronto.
Harry Wilson, C & M.E., Montreal.
C. V. Corless, M E. McGill University, Montreal.
S. J. Simpson. James Cooper Manfg. Co., Montreal.
E. W. Gilman, Canadian Rand Drill Co , Sherbrooke.
J. M. Jenckes, Jenckes Machine Co., Sherbrooke.
R. Auzias Turrene, Dawson, Y.T.
Fritz Cirkel, M.E., Montreal.
Alliene Case, E.M., British and Canadian Lead Co., Temiscamingue, Que.
Dr. A. R. Ledoux, New York.
J. C. Gwillim, Queen's University, Kingston.
Prof. S. F. Kirkpatrick, School of Mining, Kingston.
R. W. Brock, School of Mining, Kingston.
R. P. Williams, Greenwood, B.C.
H. W. Lawrence and J. S. Mitchell, Sherbrooke, Que.
J. W. Evans, C.E., Deseronto, Ont.
W. W. Leech, Geological Survey, Ottawa.
J. A. Dresser, M.A., Richmond, Que.
D. Forbes Angus, Intercolonial Coal Co., Montreal.
Dr. Alfred W. G. Wilson, McGill University, Montreal.
W. S. Dresser, Sherbrooke.
Joseph James, Actinolite, Ont.
O. N. Scott, Listowel, Ont.
Wentworth F. Wood, Kamloops, B.C.
H. C. Farnum, Detroit.
H. W. DeCourtenay and A. W. Stevenson, Montreal.
M. F. Connor, B. Sc., Ottawa.
Francis T. Peacock and Robert Musgrave, Montreal.
J. McLeish, Geological Survey, Ottawa.
J. M. Clark, K.C., Toronto, Ont.
A. S. Fraleck, Mining Engineer, Belleville, Ont.
H. W. Weller, Babcox & Wilcox Boiler Co., Montreal.
W. H. McDougall, White River, Ont.
B. T. A. Bell, Editor Canadian Mining Review, Ottawa.

WEDNESDAY MORNING SESSION.

The members assembled at 11 a.m.

Mr. Charles Fergie, M.E., the President in the Chair.

The Minutes of the last Annual Meeting and the Report of Council for the year having been printed and distributed among the members were taken and read.

TREASURER'S REPORT.

Mr. J. STEVENSON BROWN presented his financial statement for the year showing; Receipts $7,338.29; Disbursements $5,655.80; Balance in hand $1,682.49. The disbursements showed expenditures on account of publications $2,756.37; Library $655.01; Meetings $655.90; Legislation and Deputations $165.40; Secretary's office $919.26; Treasurer's office $493 86.

The report was adopted.

NEW MEMBERS.

The following new members were elected:

W. H. Johns, Elizabeth Mine, Port Arthur.
J. Errington, Massey Station Mining Co., Massey, Ont.
W. E. H. Carter, M.E., Bureau of Mines, Toronto.
Wentworth F. Wood, Kamloops, B.C.
O. N. Frechette, Montreal.
Hugh Macpherson, Ontario Powder Works, Kingston.
Daniel O'Connor, Mine Owner, Sudbury.
Alliene Case, M.E., British and Can. Lead Co., Ville Marie, Que.
Frank Cochrane, Sudbury, Ont.
Charles M. Donohoe, Boston—Richardson Mining Co., Goldboro, N.S
Col. J. Boardman Cann, Mabou Coal Mining Co., Mabou, N.S.
E. L. Fraleck, Mining Engineer, Bellville, Ont.

SCRUTINEERS APPOINTED.

On motion, Messrs. R. E. Chambers, Frederick Hobart and H. W. DeCourtenay were elected Scrutineers.

AUDITORS RE-ELECTED.

On motion, Messrs. H. W. DeCourtenay and George Macdougall were re-elected Auditors.

The meeting adjourned at twelve o'clock.

WEDNESDAY AFTERNOON.

The members met at three o'clock, the President in the Chair.

PRESIDENTS' ADDRESS.

Mr. CHARLES FERGIE who, in rising, was greeted with applause, said: It is most satisfactory to find our Council report the Institute in such a flourishing condition both financially and as regards membership, the members for 1902 being 453, showing a gain of 70 over that of the previous year. The steady increase in membership, embracing as it does the best mining men of Canada and the United States, I think is the best criterion of the Institute's worth as a Society for the discussion of the science and practice of mining and other kindred subjects. The papers published during the past year were of a high order, and will, I think, rank with those of other societies of its years and membership ; no less than one hundred papers were presented during the year. The affiliation of the students of McGill and Queen's with this Institute I consider of great importance. By being associated with us they have all the benefits of the Society in the way of receiving the publications, attending meetings, and listening to, and taking part in the discussions, and thereby profiting by the experience of the older members; they also have opportunity to write papers for the students' competition, and thereby educate and prepare themselves for work of importance they may expect to be called to do in the near future. I would strongly impress upon these students the great necessity and benefit to be derived from writing and expressing their thoughts in the form of a paper; it teaches them to think carefully for themselves, to express themselves clearly and concisely, gives confidence in themselves, and as I said before, is preparing them for the important work they expect to take up later as a profession. That this organization is of great benefit to the mining fraternity I think will not be denied, both as a medium for protection against pernicious legislation, and for the interchange of knowledge and ideas in the ordinary everyday practice of the mining and metallurgical engineer.

PROSPERITY OF COAL MINING IN CANADA.

The year 1902 has been one of unbounded prosperity for Canrda, and it is most gratifying to believe that the present one will be equalty so. The production of coal in the Dominion during 1902, was approximately :—

Nova Scotia—			
Cape Breton	3,470,449		
Inverness	120,587		
Victoria	12,037		
Total Cape Breton Island	3,603,073		
Pictou County	567,237		
Cumberland County	555,170		
Total for Mainland Collieries	1,122,407		
Total for Nova Scotia		4,725,480	tons.
New Brunswick		10,000	"
Assiniboia		69,000	"
Alberta		346,654	"
British Columbia		1,397,394	"
Yukon		2,000	"
Total		6,550,528	"

COAL TRADE.

Bituminous mined in Canada			6,550,528	tons.
Bituminous imported (round and slack)			3,806,129	"
Total Bituminous			10,356,657	
Less exported—				
Great Britain	19,986	tons.		
United States	1,854,753	"		
Newfoundland	123,738	"		
Other	91,791	"		
			2,090,268	tons.
			8,266,389	"
Add Anthracite Coal imported			951,883	"
Total coal consumption of Canada as compared with 9,334,725 tons in 1901.			9,218,272	"

A comparison of the bituminous exports shows :—

	1901		1902	
Great Britain	29 909	tons.	19,986	tons.
U. S. A	1.395,142	"	1,854.753	"
Newfoundland	83,153	"	123,738	"
Other	65,457	"	91,791	"
	1,573,661	"	2,090,268	"

Having touched generally on the coal mining operations of Canada I shall now confine myself more particularly to the progress of

COAL MINING IN NOVA SCOTIA.

The coal field of Nova Scotia is divided into three distinct districts, viz.: Cape Breton Island, Pictou, and Cumberland. The Cape Breton mines are within easy reach of the surface; the pitch of the seams is, generally speaking, very slight; they are comparatively free from fire damp, little broken up by faulting, and altogether present the most favourable conditions for large outputs and low cost of production. Referring back ten years ago, (1892) the total cost production of the Iland of Cape Breton was less than one million tons. Last year (1902) the total production exceeded three and a half million tons, and of this quantity one company—The Dominion Coal Company—are to be credited with three million tons. A gain of two and a half million tons in ten years is certainly not a bad showing, but the next decade, I predict, will greatly eclipse these figures. With the exception of Old Mines, Sydney, and where safely lamps are used and blasting explosives prohibited, the mines are worked with open lights, and black powder used for blasting coal; the mode of working is bord and pillar, coal cutting machines are rapidly displacing hand pick mining, the Dominion Coal Company producing no less than 76 per cent. of its total output by machines, and the Nova Scotia Steel and Coal Company 33 per cent., and which will shortly be increased to 50 per cent.

CONDITIONS AT THE MAINLAND COLLIERIES.

In Pictou and Cumberland a different condition of affairs exists; the seams pitch at a considerable angle, anywhere from 16° to 40°; the seams give off considerable fire-damp, and with the exception of one or two small surface winnings, all the mines are worked with locked safety lamps, and where blasting is permitted none but the so called flameless explosives are used. The mode of working is both by bord and pillar and longwall, the latter being altogether adopted in the deeper seams of Pictou County. The total output of the Mainland Mines in 1892 was 903,979 tons, that of 1902 being 1,122,407 tons. The present year promises to show large increase of output for all the mainland collieries.

Pictou is famous for its thick seams of coal, the well known Foord Pit Seam showing a section of 34′7″ of coal; and at the Albion Mines five seams show an aggregate thickness of 84 feet coal. Cumberland County field has of late years proved to be much more extensive and important than geologists formerly gave it credit, and faults which were thought to exist and cut off a certain portion of the field have not materialized; large tracts of good coal have been found instead. At the Joggins, Bay of Fundy, there is a fine exposure of the measures, amounting to more than 14,000 feet, extending from the marine limestones of the lower Carboniferous to the top of the coal formation. The beds that appear at the Joggins can be traced northeastward for many miles. The total production for the county in 1892 was 456,229 tons, and that for 1902 was 555,170 tons.

PROSPERITY OF NOVA SCOTIA COAL MINING.

In round numbers the Nova Scotia mines produced during the past year 4,725,480 tons, found direct employment for 8,500 men and boys, of whom 2,500 were employed above ground and 6,000 below ground. Nineteen lives were lost in the production of that quantity of coal, or one life for about every 248,709 tons of coal produced. During the past year no gas explosion or serious accident has to be reported, and the loss of life occurring resulted from small and peculiar accidents, incident to all coal mines.

Comparative Table Showing Tons of Coal Produced and Number of Lives Lost:

COUNTRY.	Tons (2240) lbs of Coal Produced.	No. of Persons Employ'd	No of Lives Lost.	Lives Lost per 1000 Persons Emp'oy'd	Tons Coal produced per life lost.	Tons Coal produced per annum per person employed.
UnitedKingdom*	220,000,000	493,133	1,018	2.06	216,110	446
United States†...	261,000,000	433,331	1,508	3.48	173,077	603
Nova Scotia‡....	4 725,,480	8,500	19	2.23	248,709	556

*Assumed output for 1902, correct figures not at hand.

†Return for 1901 by U. S. Geological Survey.

‡Actual production, 1902.

UP-TO-DATE EQUIPMENTS THE RULE.

Comparing the mines and equipment in Nova Scotia of to-day with those of ten years ago, one sees great improvements. Mines then producing 600 to 700 tons were looked upon as satisfactory whilst to-day 1,000 tons output is only considered moderate, and at the largest pits two thousand and up to 2,700 tons are the rule ; formerly old fashioned boilers carrying forty to sixty pounds pressure were the rule ; now we have the latest and most approved type of water tube boilers, working at from 100 to 150 lbs. pressure; large and improved up-to-date hoisting engines, and large capacity ventilating fans ; improved screening and picking plants ; the best air compressing and electric plants are now the rule ; also extensive shipping piers capable of accomodating the largest colliers, and where despatch is given second to none in the world. New and extensive mines are now being opened up and the outlook for Nova Scotia is bright and promising ; its mineral wealth is great, and it is, therefore, bound to become a great province.

IRON AND STEEL INDUSTRIES.

Not only in coal is Nova Scotia making a name for itself, but we have the large and important iron and steel works of the Dominion Iron and Steel Company, and the Nova Scotia Steel and Coal Company, both turning out a product second to none in the world, and which is finding a ready market in Canada, the United States and Europe, and which it is claimed can compete with any similar product in the world. The amount of pig iron produced during the past year was 214,293 short tons ; steel of all kinds 104,331 short tons.

GOLD MINING IN NOVA SCOTIA.

Then again we have the gold mines which produced 28,279 ounces of gold. There are now in process of construction throughout the various districts a number of large and modern plants, both for milling and mining on a large scale and to much greater depths than at present, and a considerable increase of production is looked forward to in the near future.

MACHINE MINING IN NOVA SCOTIA.

Taking the coal mines of Nova Scotia as a whole they compare favourably with the mines of the United States and Europe. Of course our mines are only in their infancy compared with either of the two mentioned countries, but I venture to predict that during the next ten years both as regards equipment and large outputs from individual mines, we shall not only hold our own but take the lead. To do this it behooves mine managers to be ever on the alert, fix their standard at a high plane, be ever watchful to make improvements, and keep abreast of the times. Should they find themselves handicapped with obsolete plant and machinery, it should be relegated to the scrap heap; the question is not how much improved plant will cost, but what can be saved by making the change. We require in working coal mines to obtain the largest possible tonnage per man employed, and to do this and compete profitably with the rest of the world, coal cutting machines must be employed, in every possible instance. Nova Scotia has started out in a very fair way to do this, for out of 4,725,480 tons of coal produced last year, no less than 2,300,000 tons, or 49%, was machine mined. This is a fair showing when we note that the United States is cutting 25% of its coal by machines, while Britain does not exceed 2%.

ELECTRICITY VERSUS COMPRESSED AIR.

Advance in science has done much in the past and will do still more towards the future successful operation of coal mines. Electricity for underground haulage, pumping, etc., is now better understood, and in the future must play an important part both under-ground and on the surface, and prove an indispensable adjunct to economy and efficiency; but in gassy mines I am inclined to think that compressed air will hold its own for sometime to come, and it is a question if the up-to-date stage compressors with intercoolers and working at high pressnre are far behind electricity in point of economy, taking everything into account, and it is not likely they will ever be displaced altogether, as it is an absolutely safe motive power, easy to handle, and so far as coal cutting machines are concerned generally, is at the present time superior to electricity. On the surface where there are a number of scattered engines around the bankhead, workshops, and saw-mills, etc., there is no question that electricity is the power to adopt to ensure economy.

COAL DUST EXPLOSIONS.

Much has been learned in late years regarding coal dust as a factor in mine explosions, and to-day it is even more dreaded than fire-damp, seeing that a very small percentage of the latter in a dusty mine is capable in case of fire of propagating the most serious of explosions, and which will carry devastation from one extreme of the workings to the other. The only safe remedy for such mines is systematic watering of the roadways and the periodical removal of accumulation of dust, and this is a matter mine managers who have dusty mines, and little gas to contend with, will do well to bear in mind. While speaking of gassy and dusty mines it is my opinion that open lights and blasting with loose black powder should be strictly prohibited by law, and that the most improved safety lamps, and some of the so-called safety explosives substituted; otherwise there can, though it may be long in arriving, be only one result—explosion and loss of life.

THE ANTHRACITE STRIKE.

The past year has witnessed one of the most severe and stubborn strikes in the history of coal mining in the United States. That disputes between capital and labor should have to be decided by such brutal methods is a reflection on this enlightened age. That the settlement of all labor disputes in future will be decided by arbitration or some other common sense method is the wish of all right thinking employers and employees. That labor organizations are lawful and have come to stay, may as well be recognized first as last; at the same time while unions have the right of organization they must be responsible in the eyes of the law and understand that in a free country a workman shall sell his labor as he pleases, and that without intimidation or coercion.

OUR HOME MARKET INDISPENSABLE.

Whilst the strike in the United States created an increased market for Nova Scotia coal, and also gave it an impetus in our own market, not nearly so much coal was shipped over the border as many imagined would be the case; the home market being so good and the imports of anthracite having fallen off most considerably, the mines had all they could do without seeking foreign markets. Another result of the strike has been the removal of the duty for one year on all coal entering the United States. That this is simply a temporary expedient to relieve the situation, and also has some political significance, will not be denied, and there is no guarantee that at the end of the year it will be continued. No sooner was this action taken on the part of the United States, than many of our Ontario friends became excited and cried out that the Dominion should likewise remove the duty on bituminous coal—there being no duty on either hard coal or coke entering Canada. Fortunately for the coal operators there are those governing at Ottawa who understand the coal situation, and have some idea of what the removal of the duty of coal would mean to the Nova Scotia mines, and it is not at all likely they will be influenced by the temporary removal of the United States duty. We have built up a good home market, a market steadily increasing, and we do not propose to hand it over to our neighbours. If the duty on Canadian coal were removed to-morrow it is not at all sure that Ontario would get her coal at any less cost than under existing affairs; that they receive no benefit or got it cheaper by the removal of the duty on anthracite is well understood by those in business.

In conclusion, I beg to thank the Council, Secretary and Treasurer for their very able assistance rendered me during the past year of my Presidency. (Applause.)

Major LECKIE—I would like to say a word, and that is I have much pleasure in congratulating the Institute upon the report of the council, showing that under your very able presidency, and with the aid of the seccretary, whose services you have referred to, the Institute has made very great progress. In 1898 the membership was 192, and in 1902 it was much more than double that—453—and beyond question we are indebted to the untiring work our secretary, Mr. Bell, for the very able way in which the Institute has been managed. Referring to your address, Mr. President, I may say that I know very well the conditions of the coal mining industry of Nova Scotia, and I have pleasure in saying that a great deal of the improvement in mining methods and mining plant is due to the initiation and example of the president of this Institute. When he came to Nova Scotia, he took hold of one of the most fiery and dangerous mines in the whole province. He has managed it not only successfully, with great engineering ability, but also financially, and I think he occupies the strongest position in both respects of any man I know of in the coal trade of Canada. As to unions, we have no need to discuss these matters; but I might say that our president has been exceedingly successful in dealing with his men and avoiding strikes and strife, and that also is a very important feature of successful management. The principle which I always followed is the same as Mr. Fergie has spoken of. The unions have come to say, and must be recognized; but the way to avoid strikes and trouble is to always urge the very best workmen to attend the union meetings, and not leave it to the shiftless and idle, who are very unsteady, but "have the gift of the gab," and do all the talking at these meetings. We know very well that when the best men control matters there will be very little trouble.

There is one thing I would like to say, and that is we had in Toronto lately what was claimed to be a mining convention, but it was fraud. The people in Toronto know very little about our Institute, and I have urged our secretary more than once to hold one of our meetings at least in Toronto. I do not remember that we have had a single meeting there since the Institute was organized. It is due to the people of Ontario but we should have a meeting in Toronto, and I am sure that it would be well attended and quite as successful as any which we have recorded in our history here. Taking the Ottawa River as a division, there are nearly double the members west of the Ottawa that there are from the east, and therefore I think that the claims of Toronto have been very unfairly ignored. I suggest that we have the next meeting there. (Applause.)

The SECRETARY—With regard to Major Leckie's remarks I may say that we intend to hold a meeting in Ontario this year, as the report of the Council shows. We should have had one of the Sault Ste. Marie last year, but the members of the Lake Superior Mining Institute, whom we had invited as our guests, could not come. The difficulty of a Toronto meeting has been first, that there has been no really suitable hotel accomodation, and our meetings have been held outside, either in the Parliament Building, or at the School of Practical Science. Much of the success of the meetings here has been due to the fact that the members have been staying at the hotel, and we get them together very easily. We have been meeting here in this Club Room since 1891, under different organizations, and we have found it most convenient. Our meetings have always been successful, and I think we have been rather chary of taking chances of meeting any where else at this time of year.

Dr. PORTER—There is one point in the president's address upon which I should like information: Has he ever worked out the number of deaths per ton of coal produced?

The PRESIDENT—I have the coal produced for life lost. I am taking the year 1901, as I could not get the figures for last year. The coal produced per life lost was: Great Britain, 216,000 tons; United States, 194,000, and Nova Scotia, 240,000. In this respect, therefore, Nova Scotia takes the lead. When, however, it comes to the coal produced per person employed, the United States takes the lead, and that is due to the large amount of machinery that is in operation there.

Dr. GOODWIN—Might I also ask a question? It has been said that the strike in the anthracite region leading to the use of bituminous coal in Canada, instead of anthracite, will lead to the permanent replacement of a portion of the anthracite. Have you been able to see any signs of it in your exports?

The PRESIDENT—I have very slightly myself; nothing like the extent that is claimed.

PRESENTATION OF PRESIDENT'S MEDAL.

Mr. O. N. Scott, of Listowel, Ont., who won the president's medal in the students' competition with his paper on "The Ore Deposits of Copper Mountain, Similkameen District, B. C." was then called forward, and in handing the medal to him, President Fergie expressed the hope that it would be the incentive to still further hard work on Mr. Scott's part. The two cash prizes of $25 each had, the president said, been awarded to Mr. H. W. DePencier, of McGill, for his paper describing "Mine Timbering in the Old Ironsides and Knob Hill Mines," and to Mr. L. P. Silver, of Queen's, for his review of "The Sulphide Ore Bodies of the Sudbury Region."

THE PRODUCTION AND EXPORT OF CANADIAN MINERALS AND METALS IN 1902.

Mr. B. T. A. BELL.—During the past two years I have endeavoured to present to this meeting such authentic figures as were available, showing the production and movement of Canadian minerals and metals during the year. I have here, open for the inspection of members, an immense amount of data, covering the year 1902. These figures show, notwithstanding a considerable falling off in the production of gold in the Yukon, and a shrinkage in value of over two millions of dollars in the mineral and metal production of British Columbia, that the total value for the whole Dominion may be conservatively stated at $71,627,528, as compared with $70,122,525 in 1901. By provinces these returns show:—

		1902	1901
NOVA SCOTIA:			
Coal	4,725,480 tons	$19,501,131 (In this estimate due regard has been made for Coal, Coke and Pig Iron re-converted.)	$13,000,000
Coke	382,989 "		
Pig Iron	214,293 "		
Steel	104,331 "		
Gold, Gypsum, Manganese, Grindstones, Barytes, Tripoli, Copper Ore and Building Materials			
BRITISH COLUMBIA:			
Gold	$5,500,000	$18 433,004	$20,713,000
Silver	4,000,000 ounces		
Copper	30,000.000 lbs		
Lead	23,000,000 lbs		
Coal	1,750,000 tons		
Coke	128,000 tons.		
Zinc, Platinum, Iron Ore, Building Materials			
YUKON:			
Gold	$12,500.000 (returns given by Canadian Bank of Commerce); Coal 2,000 tons; Silver, Platinum	$12,600,000	$18,500,000

ONTARIO:			
Copper	$686,043	$13,577,440	$11,422,525
Gold	229,828	(After deducting value domestic ore smelted into pig iron and domestic pig converted into steel.)	
Iron Ore	518,445		
Molybdenite	400		
Nickel	2,210,961		
Pig Iron	1,683,051		
Silver	80,000		
Steel	1,610,031		
Zinc	11,500		
Non-metallic	7,292,181		
QUEBEC:			
Asbestos and Asbestic	$1,500,000	$4,000,000	$3,500,000
Copper Pyrites, Chrome, Mica, Phosphate, Ferro Chrome, Iron Ore, Pig Iron, Steel and Building Materials			
NORTH-WEST TERRITORIES AND MANITOBA:			
Coal: Lethbridge	153,704 tons	$2,515,953	$1,700,000
Blairmore	75,000 "		
Anthracite	16,550 "		
Canmore	91,400 "		
Souris	64,000 "		
Gold, Gypsum, Building Materials			
NEW BRUNSWICK:			
Gypsum, Copper, Manganese, Coal and Structural Materials		$1 000,000	$1,000,000
Total mineral production of Canada		$71,627'528	$70,122,525

The following returns have been complied from the monthly Blue Books issued by the Department of Customs, and show the exports during the calendar year :—

Antimony Ore	Tons	90	$13,658
Arsenic	Lbs.	547,698	16,192
Asbestus	Tons	31,074	994.981
Barytes	Cwt.	2,500	700
Chromite	Tons	740	7,535
Coke	"	60,568	180,915
Coal	"	2,092,268	5,402,235
Copper	Lbs.	26,124,418	2,476,511
Felspar	Tons	7,374	13,699
Gold		......	16,921,861
Gypsum (crude)	Tons	289,600	295,215
Iron—Ore	"	428,901	1,065,019
" Pig	"	82,587	882,795
" and Steel—manufacturers of		......	2,007,784
Lead	Lbs.	17,761,484	457,170
Manganese Ore	Tons	162	4 062
Mica	Lbs.	1,650,902	381,812
Mineral Pigments	"	703,297	6,182
Mineral Water	Galls.	8,349	2,787
Nickel	Lbs.	14,350,721	1,007,211
Oil, crude and refined	Galls.	1,026	186

Ores—all other N. E. S	Tons	2,582	$78,854
Phosphate	"	70	1,880
Platinum	Ozs.	7	116
Plumbago	Cwt.	17,725	23,094
Pyrites	Tons	18,584	50,178
Salt		......	3 798
Sand and Gravel	Tons	159,683	118,894
Silver	Ozs.	3,422,390	1,823,058
Stone -building, freestone, etc	Tons	263,843	121,440
" ornamental and granite	"	676	3,389
" grindstones, rough	"	1,458	11,223
Other articles of the mine		......	282,735
Grand total			$34,667,169

The following figures complied from the Trade and Navigation returns show the imports of our principal minerals and metals together, with one or two items, likely to be of interest to members of this Institute : The figures are for the fiscal year ended 30 June, 1902.

Coke	Tons	266,140	$953,028
Coal and coal dust, Anthracite	"	951,883	4,239,693
" Bitiminous	"	3,300,199	6,509,061
" slack	"	505,930	267,344
Copper, and manufacturers of		......	1,557,141
Iron Ore	Cwt.	10,646,534	939,454
" Pig	Tons	75,134	1,105,972
* Iron and Steel, manufacture of	Dutiable	......	24,482,366
* " " "	Free	......	7,771,588
Mining and Smelting Machinery	"	.....	871,517
Wire rope, rigging etc	"	.....	167,307
Lead, and manufactures of		......	874,769
Grand total			$49,739,250

I am aware that these figures do not correspond with the returns issued by the Geological Survey, but, nevertheless, I am quite confident they will stand the most careful examination, and that they will be found to be an exceedingly conservative estimate of the value of the business done by our mines and metallurgical works during the past year.

The PRESIDENT—I think we are very much indebted to Mr. Bell for the time and care he has taken to give us these figures ; whatever differences of opinion there may be as to values, figures published twelve months after the close of the year cannot be of equal value to their issue within a month or two.

Mr. E. D. INGALL—Chief of the Division of Mining Statistics handed to the President a copy of the Advance Sheet issued by the Geological Survey, estimating the production of minerals in Canada during 1902 as $64,970,732 as against $66,970,732 in 1901.

The PRESIDENT—In view of Mr. Ingall's summary, I of course with-draw my statement. At the same time it does not in any way detract from the figures which Mr. Bell has presented. There are doubtless differences in computing values.

Mr. BELL—I regret very much that Mr. Ingall has not given us an opportunity to examine the figures given in his summary. As stated I am prepared to justify the figures I have given, for the returns have been furnished to me direct from the mines, from railway and navigation returns, and from reports by the directors of our Provincial Bureaus of Mines. I see no reason whatever for altering my estimate of $71,000,000 as the value of our production in 1902. Mr. Ingall's figures of the production from the Yukon do not agree with the figures reported to me by the General Manager of the Canadian Bank of Commerce, and in my judgment his estimate of the value of our nickel output is altogether too high. The discrepancy between the figures quoted by the Geological Survey for this product and those given by the Ontario Bureau of Mines is most marked. The valuation of our nickel matte should not be quoted, as the Survey states it, at the New York market quotations for refined nickel, but as the value of the matte at Sudbury. In the Annual Report of the Survey for the year 1901, issued a week or two ago, it is stated that the total value of the mineral and metal production of Nova Scotia in that year was something like $8,000,000. These figures are too low and give the public an altogether wrong impression of the relative value of the mining industries in Nova Scotia compared with the production from other provinces; moreover, I venture to say that the value of the coal output of Nova Scotia in that year, based on the selling price of coal in 1901 at the pit's mouth alone exceeded the value of the figures which Mr. Ingall has given as the total production of that Province. There is an urgent necessity for better and more prompt publication of our mineral statistics and for greater uniformity in computing values. We have at Ottawa statistics published annually by Mr. Johnson, the Dominion Statistician, we have the annual reports of the Survey, we have monthly statements of exports and imports published by the Departments of Customs and Trade and Commerce, and, in addition to these, reports and bulletins issued periodically by the Mining Departments of the different Provinces; none of them agree, and in the interest of the industries which this Institute represents I take it to be our duty to call attention to these discrepancies.

Mr. E. D. INGALL—As far as I can see the two statements practically agree. There is a certain difference of opinion as to the value to be put upon things. In Yukon gold, Mr. Bell says $12,500,000; we say $14,000,000. We had the former figures from one source and the latter from another.

Looking at the whole matter, the figures are about as accurate as you could get them. The mint is the purchaser of the Yukon gold, and its figures have been adopted. We have got the value higher than Mr. Bell, who seems to think that we estimate things too low all the time. To go into a camparison of figures like these, one should have them printed and set side by side, and wherever discrepancies occur, they should be carefully looked into, and if they are actual discrepancies, and not merely differences in price and valuation, it is then time enough to cry out that there is something the matter with them. In valuing any product, it is open to a difference of opinion as to what point you should value it at; you only value large quantities at average figures. I must compliment Mr. Bell on his industry in getting together a mass of figures like these, but I really don't see that there is anything before the meeting which can be very well discussed, unless specific points are taken up.

The PRESIDENT—What did you put down for coke, Mr. Ingall?

Mr. INGALL—$3.50. I might point out that we have not included in our general statement any pig iron produced from foreign ores, we have simply taken what was produced from Canadian minerals. Nearly all the items in our summary are made up from the direct returns from the producers themselves. When a producer says that he has made so much mineral, and that it is worth so much, you take his figures.

Mr. HOBART—The only reasonable or correct standard is the value of the metals in the ore or matte, or whatever form they are in at their final value. A standard is the main point; you must have a standard, and stick to it, or your statistics will be of no value.

The SECRETARY—I quite agree with you, but I say that the standard is incorrect. What is the standard value of nickel, or copper-nickel matte produced at the works at Sudbury?

Mr. HOBART—I should put it at the value of the metals contained.

The SECRETARY—At Sudbury.

Mr. HOBART—In the final form.

The SECRETARY—You cannot get final value until the matte has been refined at New Jersey.

Mr. GIBSON—The matter of statistics has come up at previous discussions at this Institute, and no doubt it is an important point. Statistics are practically to an industry what the barometer is with regard to the weather, or the patient's pulse with regard to his condition. They show whether an industry is prospering or the reverse. Statistics, in order to be useful, must not only be published with reasonable promptitude after the expiration of the period to which they refer, but they must also be as nearly correct as they can be made. If there is any comparison of values between these two qualities, I would lay greater stress upon accuracy than promptitude of publication. I think that the Geological Survey has for the last few years published its statistics with unusual promptitude after the close of the year. Its preliminary statement has been brought out a couple of months after the end of the year, and its final statement, in which much greater detail is given, usually comes out a year or little more after the period for which it is issued

With regard to Mr. Bells's statistics, and also with regard to Mr. Ingall's, as published in his preliminary report if I wanted to criticise, I think I could point out some ways in which both are imperfect. For instance, Mr. Bell has included the value of all the iron ore produced in Canada, and he gives us the value of all the pig iron ore produced in Canada and he gives us the value of all the pig iron produced very largely from that same ore. He also includes the steel which is produced from the pig iron produced from the iron ore; so that we have in this case the values duplicated at least twice. Again, we have the value of the coal given, and the value of the coke produced from the same coal. After all it matters little what basis you adopt for the valuation of statistics, as long as it is understood: but if we wish to get an absolutely correct value of the mineral production of our country or province, I don't think it is right to include the same mineral in two or three different forms.

In the statistics of the Geological Survey, the item that Mr. Bell has taken exception to is, I think, properly open to objection. The value of nickel and copper in the nickel-copper matte produced in the Sudbury region should not be valued at the price of the refined metal in the New York market, any more than the price of a shipment of wool should be valued at the price of finished tweeds, or pulpwood at the price of the paper produced from it. I contend that the proper valuation to place on the nickel-copper matte of the Sudbury country is the value at which it would sell at the works at Sudbury, and that is the value which I have endeavored to put on it in the statistics I prepare from year to year. It varies according to the grade of the matte. The value of the copper matte made at Sudbury now is worth more than it was a few years ago, because it is brought to a higher metallic value.

There is a good deal in the way in which you look at statistics. If you have the proper quantity before you, you can fix the valuation. For the purpose of Ontario, I think the value to Ontario is the value of the products at the time they leave the country, and not after all the additional labor has been put upon them in refining them into the actual metals.

Mr. B. T. A. BELL—In reply to Mr. Gibson I may say that in my statement I have, while quoting the figure of the output of coal, coke, pig iron and steel, made a generous allowance for the reconversion which Mr. Gibson has referred to. My figures have never been intended to be complete, but I do contend that they are a fair conservative estimate, suitable for the purposes of this annual meeting.

Major R. G. LECKIE—I quite agree with Mr. Gibson that the first essential is to have the quantity accurate, because values are very, very uncertain. Looking at the statistics which have been presented by the Geological Survey, I see the production of copper is put down at 30,000,000 lbs., and is valued at 11¼ cents per lb. In Canada it is not worth much over 9 cents. The value is continually varying. The production of nickel is put down at 10,000,000 lbs , and the value at $5,025,000, which is equal to 50 cents a lbs. Half that price would be more than the value in Canada.

Mr. HOBART—While I don't want to take back anything I said a short time ago about the standard, I quite agree that quantities are the more important part. The determination of values is a very difficult matter, but if we have the quantities we have the main thing.

Mr. EUGENE COSTE—I am entirely of Mr. Gibson's opinion with regard to the valuation at the mines or works. That very fact explains a great deal of the trouble that seems to be between our secretary and Mr. Ingall. I think that much of that difference is entirely due to repetition in some cases and omissions in others, and that want of system is at the bottom of the whole thing. I have prepared a little paper on the collection and publication of mining statistics, and perhaps the present would be a good time to read it. Mr. Coste then read his paper.

Mr. HOBART—With regard to Mr. Coste's proposition, his point is all very well in one way—the satisfaction of mere curiosity—but it seems to me an unnecessary duplication of figures. The main object of statistics it to serve as a guide to the trade. The man who deals in copper does not care how much ore is produced ; what he wants is copper. To go into all these figures of the production of ores is a multiplication of labor, without any useful purposes. The copper, as it comes from the mines, would in most cases have no value at all, unless submitted to concentration or smelting, or whatever may be necessary. I don't see the object of going into all these requirements, spending a lot of time and money, and more especially the time spent in collecting all these figures, when they are not going to do us a bit of good. I must also differ from Mr. Gibson, as I believe that promptitude is in many cases of more value than absolute accuracy. We cannot expect in any case absolute accuracy as long as we have men to deal with, but if we can get it by March 1st, as the Geological Survey has done, it is worth much more to the average dealer, consumer and producer than it would be to have it absolutely accurate a year from now. One man, who deals largely in copper said to me: "I would rather know on February 1st, the amount of copper produced, within 5 per cent., than know the whole total two months later." I think you will find that opinion among all people engaged in trade.

Mr. B. A. C. CRAIG—I think the best way to state value would be to give it at some selling point, and state how it had been determined upon. From my experience of Mr. Ingall, I have found him extremely persistent in his demand for statistics and figures. I don't think he has been at all lax, but I do think that almost any ordinary statistical returns that you pick up give little or no information, for the reason they don't set out in detail how they have been compiled. I think that Mr. Coste's suggestion is a good one.

Mr. BELL—Figures after all have but a relative value. The Province of Nova Scotia produced last year four millions of tons of coal but how many people realize what these figures mean to the trade and commerce of the country—the invested capital in land, buildings and plant, in wages, in the purchase of supplies, the rail and water freights, harbor dues and pilotage, in Government revenue from customs and royalty. Something more than a bald statement of figures should be given to the community so as to convey to the public a proper estimate of the value of mining as a Canadian industry.

Dr. ROBERT BELL—In order to justify myself, I beg to state that I was the first collector of mineral statistics in this country, collecting them since about 1860. They were published in the *Montreal Herald* for many years and in the *Globe*, Toronto, as well as in the *Mining Journal*, New York, and the *Mining Journal*, London. Therefore I may, perhaps, be excused for taking up your time for a few moments. The difficulty in making accurate statistics can hardly be over-estimated. Anyone who has collected statistics knows it. Mr. Bell and Mr. Ingall are practically agreed as to quantities; the difference is in estimating values. If we are going into values, I think the value should be the worth when converted into some form in which we can compare it with other countries, the first tangible value itself. If you make a ton of iron ore into hair watch springs, it becomes worth $1,000,000 a ton. I believe that Mr. Bell is entirely sincere in all he has said, believing the same to be true, but it all depends on the way you estimate your values. I don't see why there should be any difference between the figures; we get them officially, and Mr. Bell gets them unofficially.

The SECRETARY—I beg your pardon; I get them officially. You are quite at liberty to examine my authorities. Here they are.

Dr. BELL—If the statistics are right as to quantities, all the rest can be easily adjusted.

Mr. CRAIG—I think there is more in this matter than merely collecting statistics, and without wishing to criticise the department, I doubt that perfection has been obtained by any means. If Mr. Coste would nominate a committee to deal with the matter, I would be very glad to second the motion, because I think it is of immense importance.

Mr. INGALL—I am glad to hear the suggestion of the last speaker, because it will put the suggestions which have been made in such shape that they can be acted upon. I quite agree with Mr. Craig that we are very far from perfection, but we shall get nearer to it if the practical men of the country will embody their suggestions in definite shape.

Mr. GIBSON—The suggestion that a committee be appointed to deal with the matter of statistics is worthy of consideration. It has always been our endeavor in Ontario to present the statistics fully and accurately. We have not always thought in the past, however, that we have been assisted as we might have been by the mining men of Ontario; but by dint of perseverance we have usually succeeded in getting approximately at the point at which we wanted to arrive. I am quite aware that the statistical schedules published by the Bureau of Mines and the Geological Survey at Ottawa are capable of improvement. If fuller details are wanted, we shall be happy to furnish them, if we can get them. If a committee is appointed, I shall deem it a privilege to co-operate with it.

Mr. OBALSKI—As inspector for Quebec, I should like to join that committee and give my experience on the subject.

Mr. COSTE—I don't quite agree with some of the speakers who look upon quantities as the most important point in our mineral statistics. From quantities we cannot make a total; we cannot add ounces, pounds, tons and barrels together. That is one point which, to my mind, forces us to settle down on some system and some values to be adopted in all the provinces of the Dominion, so that we can arrive at a total which will show the state of the barometer, whether it is rising or falling. It should not be very difficult to get at a standard of value. If metallurgical works are increasing and a higher matte produced, we want to know it. It seems to me that the value should be taken at the mine or at the works every year in the conditions in which the mineral or metal is sold by the works.

Mr. HOBART—I would like to ask Mr. Coste: "How are you going to get your values without getting your quantities first?"

Mr. COSTE—There are two ways of getting at values, but the most direct is to get them out of the books of the producer or miner. In some cases the mining men of the country are enlightened enough to understand the value of these statistics, and if they are quite sure that their particular values will not be disclosed and that their productions will only be grouped with others, so that their own business will not be published, in most cases producers, miners and smelters will take the values right out of their books. Very often you know the value better than you know the quantity. By the system I suggest, you can value your ore, your matte and your finished product, and you don't repeat. The great point is statistics, to my mind, is clearness, and by this system you are always clear.

The following Committee was appointed to deal with the main question and to report at the next annual meeting: Messrs. Fergie, Hardman, Coste, Bell, Craig, Gibson, Obalski, Ingall and Haanel, with power to add to their number.

WEDNESDAY EVENING.

The members met at eight o'clock, the President in the Chair.

IRON ORES OF MESABI.

Prof. C. R. LEITH of Madison, Wis. opened this session with an interesting address on the "Iron ore deposits of the Mesabi district," the subject being well illustrated by lantern projections.

Mr. E. D. INGALL—What is supposed to be the relationship of the Mesabi Rocks to the rocks in the Thunder Bay district of Ontario? I have worked in the latter region and the slides shown were identical reproductions of those we had. I know that you have seen the two districts, and I was wondering what the relationship was supposed to be.

Prof. LEITH—We believe the two regions to be continuous. We have followed the Mesabi material from Gunthorpe Lake to Thunder Bay, and we have no reason for believing that they are not absolutely the same.

Prof. MILLER—We are under much obligation to Dr. Leith for coming such a long distance and giving us this paper. The subject of iron ores is a very important one in Canada at the present time, especially in Ontario; and I think that Quebec has hopes of finding iron ores. The district to the south-west of Port Arthur is being tested. There are two drills at work there for private parties, one of which, I understand, has Senator McInnes at its head, and the other is a Canadian company. The men who are doing work are experienced iron men, who have examined the district thoroughly. I think the district is promising. That is about the only area we have in Ontario that resembles very closely the Mesabi range. We have other ranges which resemble the Vermilion. These ranges practically surround Lake Superior on our side of the boundary. One range can be traced across the district of Nipissing for a distance of about eighty miles, and the western outcrop has attracted much attention lately in the township of Hutton. We are very pleased that an iron man of such high standing as Dr. Leith has come over and made some references to that district. One thing we lack in this country is knowledge of the deposits similar to those of Mesabi. It is no use sending an expert to examine deposits in our northern district who is not familiar with those of Wisconsin or Minnesota, because they are unique. They send out experts from England occasionally to examine these districts, but they don't know much about them. We expect that great interest will be taken in our iron deposits during the next few years. Many deposits were tested last summer in a crude kind of way, and drilling was done on a number of outcrops. The only producer we have at present is the Helen Mine, in the Michipicoton district.

On the motion of Mr. Coste, seconded by the Secretary, a hearty vote of thanks was accorded Professor Leith for his address.

MINING IN ONTARIO.

Mr. T. W. GIBSON, Director of Mines,—It is not my purpose to speak at any length on this subject to-night, but I have in my hand the statistics of the mineral production of Ontario last year, and these will form a text on which I shall hang a few remarks to show what progress we have been making in that province during the year. It is not so long ago that people were sneering at the claims of Ontario to be considered a mining province at all. It was looked upon as being pre-eminently an agricultural province, and it is only in late years, comparatively recent years, that its claims to be considered a producer of minerals, on anything like a considerable scale, have been justified. He submitted the following comparative statement showing the output in 1902 compared with the previous year:—

MINERAL PRODUCTION IN ONTARIO FOR 1902.

PRODUCT.	1901.		1902.	
	Quantity.	Value. $	Quantity.	Value. $
Metallic :				
Copper.................lb.	9,074,000	589,080	9,864,000	686,043
Gold ....oz.	14,293	244,443	13,625	229,828
Iron Ore.............tons.	273,538	174,428	359,288	518,445
Molybdenite........... lb.	....	....	6,500	400
Nickel..................lb.	8,882,000	1,859,970	11,890,000	2,210,961
Pig Iron.............. tons.	116,370	1,701,703	112,687	1,683,051
Silver..................... oz.	151,400	84,830	145,000	80,000
Steel.....................tons.	14,471	347,280	68,802	1,610,031
Zinc Ore................ tons.	1,500	15,000	950	11,500
		5,016,734		7,030,259
Less value domestic iron ore smelted into pig iron and domestic pig iron converted into steel.....		400,000		745,000
Net value metallic output..		4,616,734		6,285,259
Non-Metallic :				
Actinolite. ....tons.	521	3,126	800	6,150
Arsenic...............lb.	1,389,056	41,677	1,600,000	48,000
Building stone, etc.........	....	850,000	....	1,020,000
Carbide of Calcium...tons.	2,771	168,792	1,402	89,420
Cement, natural rock..bbl.	138,628	107,625	77,300	50,795
Cement, Portland.....bbl.	350,660	563,255	522,899	916,221
Corundum ....lb.	1,068,000	53,115	2,273,211	83,871
Brick, common.......No.	259,265,000	1,530,460	220,500,000	1,411,000
Brick, paving ....No.	3,689,000	37,000	4,210,565	42,000
Brick, pressed and terra cotta..............No.	12,846,000	104,394	19,755,496	144,171
Felspar.................tons.	5,100	6,375	8,776	12,875
Graphite..................tons.	1,000	20,000	1,923	17,868
Gypsum............... tons.	1,554	13,400	1,917	19,149
Iron Pyrites..........tons.	7,000	17,500	4,371	14,993
Lime.............. bush.	4,100,000	550,000	4,300,000	617,000
Mica.......................lb.	854,000	39,780	1,986,000	101,600
Natural Gas............ .	....	342,183	... .	189,238
Pottery.	....	193,950	....	171,315
Petroleum......Imp. gals.	21,433,500	1,467,940	21,630,000	1,600,000
Salt.......................tons.	60,327	323,058	62,011	344,620
Sewer Pipe..............	....	147,948	....	191,965
Talc..................... tons.	400	1,400	697	930
Tile, drain. ....No.	21,592,000	231,374	17,510,000	199,000
Total Non-Metallic.......		6,814,352		7,292,181
Add net value metallic output..................		4,616,734		6,285,259
Total production..		11,422,525		13,577,440

The mineral products of Ontario for 1902 considerably surpassed in volume and value the output of any previous yaar. The total of production was $13,577,440, an increase of $1,746,354 or 19 per cent. over 1901. Metallic products contributed $6,285,259 and non-metallic $7,292,181, both classes showing an excess as compared with last year's figures.

The chief increases were as follows :

	1901	1902	Increase
Copper	$ 589,080	$ 686,043	$ 96,963
Iron Ore	174,428	518,445	344,017
Nickel	1,859,970	2,210,961	350,991
Steel	347,280	1,610,031	1,262,751
Stone	850,000	1,120,000	170,000
Cement	670,000	967,016	296,136
Lime	550,000	617,000	67,000
Petroleum products	1,467,940	1,600,000	132,060
Mica	39,780	101,600	61,820

And the principal decreases :

	1901	1902	Decrease
Carbide of Calcium	$ 168,792	$ 89,420	$ 79,372
Brick, common	1,530,460	1,411,000	119,460
Natural gas	342,183	189,238	152,945
Tile, drain	231,374	199,000	32 374

Notwithstanding some slackening of production at the principal nickel mines and works of the Sudbury region, the output of copper and nickel was the largest yet recorded, the former being 17 per cent. and the latter 35 per cent. in excess of the yield for 1901.

In iron ore there was also a large gain, the production increasing in quantity from 273,538 tons to 359,288 tons, and in value from $174,428 to $518,445. The bulk of the ore, as in 1901, was raised from the Helen mine, Michipicoton, where other important deposits of hematite are also in course of development.

The production of pig iron was slightly under that of 1901, blast furnaces finding it difficult to procure regular and adequate supplies of coke. The falling off as compared with the product of last year was 3,683 tons in quantity, and $18,652 in value.

The very decided increase in quantity of steel produced from 14,471 tons worth $347,280 in 1901 to 69,802 tons worth $1,610,031 in 1902, was mainly due to the starting up of the Clergue works at Sault Ste. Marie.

Building and construction materials in the main show an increase, particularly stone, which includes also crushed stone for pavement use, and cement. The Portland cement industry is being firmly planted in this Province, where immense supplies of the raw materials for its manufacture exist. Eight plants were at work in 1902, and since the beginning of the present year another large factory has come into operation. Three or four others are under construction. In addition, natural rock cement is being made at four different establishments. The total output of cement rose from 489,288 bbls worth $670,880 in 1901 to 600, 199 bbls. worth $967,016 in 1902. There appears to have been a falling-off in the production of ordinary building brick.

Mica shows a large praportionate gain, while the output of natural gas has shrunk to little more than half the dimensions of 1901, in consequence largely of the withdrawal of permission to export this article

The yield of petroleum remained almost stationary. The value given in the above table is that of the refinery products together with the value of the crude used for gas and fuel purposes, in which a much larger share of the product is now employed than formerly.

Mr. COSTE.—I should like to ask why, in the petroleum production, Mr. Gibson has used the finished product figures, instead of the raw material. The figures of $13,500,000, which Mr. Gibson quotes as the total mineral production of Ontario last year, include the petroleum in the shape of the finished material—paraffin wax, lubricating wax, and so forth. I don't think that is right. You might get your production to $20,000,000, if you valued the products in that way. It gives a false impression. I would like to emphasise what I stated this afternoon, that there is no system to the thing. We want to know the mineral production of the country. We don't want to take a mineral product and value it up to its last limit, the finished article, and then call that the mineral production of the country ; it is not the production of our mines at all The sooner we realize that, the sooner we know what we are dealing with. There is no use of fooling ourselves, as the saying is, and I think that in this case we do.

Mr. GIBSON.—This question was gone into this afternoon at some considerable length, and I don't think it would be edifying to have a repetition of it. There is a difference of opinion in making up statistical schedules, and a committee was appointed to consider it and make recommendations, and think that it might very well be left to that committee. One of the values of schedules of this kind is that one year's work can be compared with another, and when you preserve the basis which has been adopted in former years, you can compare one set of figures with another. When you change the basis, you lose that advantage. Figures like these can only be approximate.

On the motion of the president, a cordial vote of thanks was passed to Mr. Gibson, and the session adjourned.

THURSDAY AFTERNOON.

The meeting of the Institute was resumed at three o'clock in the afternoon of Thursday the 5th March.

Mr. Charles Fergie, President, occupied the Chair.

ECONOMIC GEOGRAPHY.

Mr. James White, C. E., F. R. G. S., Dominion Geographer, Ottawa, presented a most interesting paper " On Economic Geography. "

At the conclusion of his paper Mr. White said, pointing to the handsome map of the Dominion on the wall, recently published by the Department of the Interior : This map will be used to a certain extent in connection with the Economic Atlas. Before I left Ottawa I saw the Minister of the Interior and he gave me permission to say that a copy of this map properly mounted will be donated to the Institute, and that an unmounted copy will be sent to each member.

The PRESIDENT (Mr. Fergie) said. We are all much indebted to Mr. White for his interesting and instructive paper and especially for what he promises in the future as regards maps and diagrams, which will be no doubt of inestimable value.

Major LECKIE—I heard Mr. White's paper with a great deal of pleasure for it gives us a clearer idea of the resources of the country than we had before. The development of those resources come quite within our scope as an Institute. The water power of Canada is unrivalled in the world. I have been in Norway and Sweden for some years past, and after what I say there I can say that Canade eclipses the world in the matter of water power. Really our water powers are the equivalent of our coal fields. Take the Sault and there you have the whole of Lake Superior as a mill pond, and the power that can be made available there is incalculable. It is equal to I do not know how many thousands of tons of coal per year, and we have in all those rivers, from Lake Superior to New Brunswick, water power, which represent an enormous amount of fuel. In the Lake Superior district and in North Ontario, we have no coal but we have the equivalent in enormous water powers. The Department of Government which Mr. White represents is doing an immense service to Canada in bringing these things before the country.

Dr. GOODWIN—There is an interesting incident known to some of us which illustrates the point that water takes the place of fuel to generate power for mining and other purposes. Some of you who know the Cordova Mine know the amount of wood and coal that it took to generate power, but within a recent period they have developed a water power two miles away, and now they are independent of the coal barons to the south. That is a beautiful illustration of this very point, and that will be repeated over and over again in Canada as time goes on. In that way we solve the problem of cheap fuel.

Mr. WHITE—The branch of the Department, of which I have the honour to be the head, is to a large extent a new thing, and our first piece of work has been the large map of the Dominion. We also produced a smaller one on a scale of 100 miles to the inch. From this time forth we propose to develop as far as possible on the lines of commercial geography with the view of advertising the resources of the country. If we can place a copy of the Economic Atlas in each business house in Great Britain and the United States, it will do more to advertise Canada than anything else I can think of. If we can do that, it will be a revelation to 99 per cent. of the people of Great Britain and of the American Republic

Mr. COSTE—I would like to congratulate the Canadian Government and the country on having secured my friend Mr. White for the position he now occupies at the head of this Topographical Branch. Some years ago Mr. White and I were on the same Survey and I learnt then to appreciate his ability. The difficulties before him are, no doubt, very great, but I have no fear but that he will overcome them. The importance to the country at large of first-class maps is self evident, but it is especially evident to those who have tried to make surveys with the existing maps and know their deficiency. The state of our maps has been deplorable up to date. I would like to ask Mr. White if a geodetic survey of the whole country is to be undertaken before long so as to lay the foundation for very correct maps? I would like to see the work undertaken by the Dominion Government in a systematic way.

Mr. WHITE—I cannot really say whether the Department proposes to undertake a geodetic survey of Canada. For a great many years to come we will have to depend on what are called geographical surveys. These surveys carried on in the past have not been what they should be, and the information on our maps hitherto has not been as detailed as it should have been. What Mr. Coste refers to can only be accomplished by the expenditure of more money, but I have every reason to believe that it will come in time. The geodetic survey means the carrying of a triangulation over the whole country, which is a very slow process indeed. There is no use in having one Department doing a lot of work and another Department doing other work, and overlapping each other. What I have always advocated was the formation of a Geographical branch which would undertake all this work, and go into it with ability and expedition. The present system of letting the work out to different Departments results in a waste of time and a waste of money.

On the motion of the President a cordial vote of thanks was tendered to Mr. White for his valuable paper.

THE STEWART RIVER GOLD DREDGE.

Mr. A. W. ROBINSON, C.E., of Montreal, presented his paper "On the Stewart River Gold Dredge" (reproduced elsewhere.)

Mr. J. E. HARDMAN—Might I have permission to question Mr. Robinson with regard to one.of two technical points. He told us that his dredge was of the Californian type rather than the New Zealand type. Might I ask him whether these holes in the screen are of uniform size or whether some are smaller and some larger than the others. Those of you who read the Canadian Mining Review of last month may have noticed a comparison in the methods of dredging between the New Zealand type and the American type and the expression of opinion given thereon. Might I ask if the buckets in the Stewart River Dredge are close together, and if not, what is the distance approximately between the bucket pins?

Mr. ROBINSON—The holes are from an inch to three inches and are not of uniform size; at the lower end there are a few holes six inches by three. The size of the holes depends largely on the size of the stones to be dealt with. The buckets are open spaces with intermediate links, and the capacity of the bucket is two and a quarter cubic feet. I was the first one to introduce the close bucket type for dredges built some years ago in Montana. Those who used them seem to like them, and they claim that they work at bed-rock better than the buckets further apart. There are arguments in favor of both sides, but close buckets are heavier than the other system and not as well adapted for lifting big stones. Accidents happened on the Montana dredge by big stones getting between the buckets, but in this type of bucket that does not happen.

Major LECKIE—A year ago I was in New Zealand and saw the dredges at work there. The rivers are rather deep in that country and the sand free from boulders, so that they could use a different type of dredge. My friend Mr. Errington, when he was up the Vermilion River, in our Northern Ontario, found that there were a great many large boulders in the bed of the stream which would prevent the use of the New Zealand type, although on certain other rivers they might advantageously be used. It would appear that the machine would have to be modified to suit the conditions of each river I was very much pleased to hear this paper read by Mr. Robinson. I happen to know the President of the company very well and I know that the financial affairs are in the best of hands. If this dredge does not succeed, considering the financial and mechanical skill displayed, then there is very little hope for success in that business.

Mr. ERRINGTON—What size of boulders are handled, and is the ground loose or solid?

Mr. ROBINSON—I think the gravel is comparatively loose. Of course we do not know what is beneath the surface, and as they have to work over a good many miles of river they would encounter all kinds of material. I may say that the dredge can come up against immovable rocks without injury to itself. We handle stones in that dredge up to 18 inches in diameter and pass them through.

Mr. ERRINGTON—How would you do when you came to large boulders? Do you work around them or up against them?

Mr. ROBINSON—You have to do the best you can, but in the hands of a skilful man there is no danger.

Mr. ERRINGTON—The gold on the Vermilion River is coarse enough to look at, but in reality it is comparatively fine; it is sort of flakey. On account of there being such large boulders there I was not aware that you could make any headway with a dredge of that kind.

A cordial vote of thanks was tendered to Mr. Robinson for his valuable paper.

REMARKS BY DR. LEDOUX.

The PRESIDENT—We have with us this afternoon a very distinguished visitor in the person of Dr. Ledoux, of New York, President of the American Institute of Mining Engineers, and I wish you to join with me in giving him a very hearty welcome.

Dr. LEDOUX, who was warmly received, said: I thank you in the name of the American Institute of Mining Engineers for welcoming me to your meeting. I have been a member of this Institute for a number of years and I always have great pleasure in attending your meetings. One of the most pleasant things is that you find so many men of one Institute who are members of the other. The relations of the American Institute with the Canadian Institute are most cordial, and most friendly, and they have been working largely on the same lines. I again express my pleasure in being with you.

ON THE MODERN BLAST FURNACE LABORATORY.

Mr. W. DICKSON, CRAIG, of Midland, Ont., presented a most interesting paper "On the Modern Blast Furnace Laboratory and its Work."

The PRESIDENT—There are some chemical gentlemen connected with the Institute who are fully competent to discuss Mr. Craig's paper, but I regret they are not in the room at present.

Dr. LEDOUX—I have been making some notes while Mr. Craig was reading his paper, not because I had any idea of discussing it but in order that I might get some ideas for the laboratory in New York. I remember that in the laboratory in London they had extraordinary difficulties in their assays. They had their balances tested and tried everything to discover what the difficulties were, but at last they found that it was in some way connected with the electric light which affected the balance. When the light was some distance from the balance, one arm of the balance, or the other, would be suspended or lengthened, but when they did away with the electric lamp all these discordant results disappeared. I mention that as showing how careful we must be about the construction of the laboratory, aud how we should watch the effects if it is illuminated with electricity. The desideratum is to get the light near enough to have the full benefit of it, and at the same time not too near to get heat from it. With regard to the floor being cemented, we tried that in New York, but we found in time that the friction would wear away the cement, and our experience was that a very hard asphalt makes a better floor. The arrangements of the windows in the laboratory is a very important matter because you want to get light, and at the same time be able to keep the windows opened without having the wind blowing over the desk. As to the sampling of cargoes of iron and ore that is the most important point Mr. Craig has raised. If your sample is wrong there is no use making a careful analysis of it. I know that conscientious assayers have to meet competition from men who simply take a cigar box and fill it from a cargo and then say they have a proper sample. You cannot have too large a sample, and facilities for preparing it are equally essential. There are many ways of sampling cargoes of iron and ore besides merely taking a shovel full out of every tenth bucket. The old method of having a rod, with knots on every two feet, and having a man take a lump however small it might be, and putting it in the sample pile, gave you a very fair sample. I am delighted to hear that in Mr. Craig's case they have taken such pains with their laboratory. Not only it is important for the works themselves to have the best analysis, but it is a matter of importance for those who sometimes have to stand between the buyers and sellers of ores and their products—sometimes we find that no matter how painstaking a man may be, another man may not be so painstaking, and the tendency naturally is for each man to think that his own analysis is right.

Dr. GOODWIN—I am glad that interesting papers of this character engage the attention of the Canadian Mining Institute. I say that because I am a chemist myself, and I believe that we do not have half enough chemistry talk at our meetings. I generally hear discussion about geology, and mining, and machinery, but very little about chemistry, and we all know that chemistry is a most important branch of the mining industry. Mr. Craig's description of the methods which have been adopted at the Midland Iron Furnace has value in several respects, In the first place it will be a valuable paper for students to consult in order to give them a clear idea of the kind of work they will have to undertake when they get into business themselves. The description of the methods which can be carried through in twenty-four minutes of half an hour will give the student a clear idea of the rapidity into which he will have to alter his slow fingered work while he is at the scientific school. Mr. Craig's suggestion as to what the Government might do in encouraging the selection of standard samples is most important. The description of the laboratory I found very interesting, and, like Dr. Ledoux, I made notes of the suggestions which perhaps I may be able to embody in improvements which are to be made in our own laboratory in Kingston. We are all much indebted to Mr. Craig for this interesting paper.

Mr. GEORGE E. DRUMMOND—I listened with very much pleasure to the able paper of Mr. Craig, and I am pleased to know that Dr. Ledoux was able to express his commendation of the work we are trying to do at Midland. We have a great deal to do there before we make ourselves perfect, but there is one thing which I am sure you will have noticed and that is that we have a good chemist (applause). The chemistry of the thing is what we want to get down to in this country, and for that reason many of us who are engaged in manufacturing are beginning to make an interest in technical education. We have suffered in Midland, and I suppose others have suffered also, as to the methods adopted for sampling at the port of shipment as against the methods adopted at the port of delivery. The question of uniformity is a very important one. Chemistry is most important in our business, and the manufacturers are beginning to realize that. In trying to make our laboratory at Midland as perfect as possible we feel that we are going on the right line. We try to have a good Superintendent and good workmen, and, having heard our chemist, you will see that we have succeeded in getting a good one.

On the motion of the President a cordial vote of thanks was tendered to Mr. Dixon Craig, for his paper.

ON SOME POSSIBILITIES IN CANADIAN MINING.

Mr. FREDERICK HOBART, M.E., of New York, presented his paper on "Some Possibilities in Canadian Mining," (reproduced elsewhere in this volume.)

ON MINERAL STATISTICS: CANADA AND UNITED STATES COMPARED.

Mr. GEORGE E. DRUMMOND, presented a paper by Mr. George Johnson, Dominion Statistician, giving a comparision of statistics of mineral production in Canada and the United States.

Votes of thanks were tendered to Messrs. Hobart and Johnson for their contributions to the transactions of the Institute.

THURSDAY EVENING SESSION.

The members met at eight o'clock. Mr. Charles Fergie President in the Chair.

THE VOLCANIC ORIGIN OF NATURAL GAS AND PETROLEUM.

Mr. EUGENE COSTE, E.M., Toronto presented a valuable paper on the subject of "The Volcanic Origin of Natural Gas and Petroleum."

Dr. ROBERT BELL—Mr. Coste has made out a theory that there may be a connection between petroleum and gas and organic phenomena, but I expected he would go further and show how all the elements are derived; how from the disassociation of the elements of other substances petroleum is formed.

Mr. COSTE—I do not pretend to be enough of a chemist to explain all the reactions in the volcanic phenomena. It is too complicated a problem for that, and the conditions down below, where extraordinary temperatures and pressures must necessarily exist, are so much at variance with known conditions that I, for one, am not prepared to go into minute chemical explanations. For the present, at any rate, I am quite content in pointing out that we clearly see in the volcanic emanations large quantities of hydro carbons, sulphuretted hydrogen, chlorides and steam. All these gases and vapors have been collected right from the lava themselves, and it is proved beyond a doubt that they are among the products of the volcanic activity as seen all over the world today and as manifested in past ages. This is a very plain geological fact. I concern myself with it only, leaving to future generations to say what all the reactions are down below.

Major LECKIE—We are all indebted to Mr. Coste for his very erudite paper, but I think it tries to prove too much. All these oils are not of regular chemical analysis. They vary in their constituents, and in the proportion of their constituents. While not desiring to controvert this theory of volcanic origin, I think that there are evidences of oil having been produced from the shales. Take the Albertite, in New Brunswick: through the bituminous shales there, there are regular fractures and these fractures are filled with solidified petroleum. There is evidence that it has filtered in from the bituminous shale through which the fracture runs.

Mr. COSTE—Where was the pressure that would drive this bitumen from the shales to the fractures?

Major LECKIE—It does not require any pressure.

Mr. COSTE—On the contrary, you cannot drive anything through shales without enormous pressure as they are almost absolutely impervious.

Major LECKIE—We find that the fractures are filled by a regular infiltration. I can remember a discussion in this city at a meeting of the American Institute of Engineers when Mr. McFarlane, Chief Analyst of the Government, took the ground that a great deal of this natural gas and petroleum in Pennsylvania was the result of the volatilization of the volatile matter of the bituminous coal; the conversion of bituminous coal into anthracite.

Mr. COSTE—In the Welland County gas field of Ontario, we have two gas sands only 125 feet apart in the vertical scale, and yet as proved by our gauges, the pressures in them remained at a difference of 125 lbs. per sq. inch for aeons of ages. That cannot be controverted in any manner, and shows, absolutely, the imperviousness of these strata, which are not even all shales as a large part of the 125 ft. are sandstones. Therefore, as I point out in my paper, it is impossible, on account of the imperviousness of the strata, to imagine natural gas and oil to have travelled long distances sideways to Anticlines and to have been brought there without any pressure whatever to drive them. How could they travel miles through such strata as that when they will remain for ages in that way without mixing at 125 lbs. difference of pressure between two strata only 125 feet apart?

Major LECKIE—I think the oil has a different origin and that is very evident from the manner in which we find it to-day.

Mr. MICKLE—I would like to put this question as a conundrum: What is the difference between the man who believes in the exclusively vegetable origin of coal and a vegetarian.

Major LECKIE—That is a puzzle.

Mr. HARDMAN—Perhaps Mr. Mickle can answer that himself.

Mr. MICKLE—The man who believes in the exclusively vegetable origin of coal is prepared to swallow anything, and the vegetarian draws the line at meat. (Laughter).

Dr. ADAMS—We are indebted to Mr. Coste for his very able paper. It contains so much that may be discussed with profit that we can hardly hope to do it justice within the time allotted. It is a paper which should be discussed by correspondence, the remarks of those discussing it appearing as an appendix to Mr. Coste's paper. There is one thing which strikes everybody, and that is, that the paper has been written by a gentleman who has been educated in France. We find that at the very earliest times the French geologists had always had the greatest respect for the earth's interior which none of us know anything about. For instance, we are told that by emanations from the earth's interior, whole mountains of limestone and shale are converted into granite.

Mr. COSTE—That is not in my paper.

Dr. ADAMS—It is not, but Mr. Coste has derived from the earth's interior coal oil and all other things, and it is part and parcel of the same theory. We ought to be very thankful to Mr. Coste for the paper, in which I can safely say he has got together every single fact that can be adduced in favor of the volcanic origin of petroleum, and a good many which cannot be adduced in favor of it. With regard to the albertite, it seems to me plain that it is not volcanic at all. We have in Albert County a series of bituminous shales filled with fossil fish from which it has always been supposed the albertite was derived. At the Albert Mines these are traversed by an anticline, on one side of which the pressure developed a fissure or crack. If you take a ton of this shale and heat it you can readily drive out of it a large amount of bituminous material. If you have this crack opened in a mass of shales saturated with bitumen, it seems to me it is reasonable to suppose that a certain amount will slowly ooze out and as the crack widens it will fill up. There is no evidence of volcanic action in the vicinity. When they started the mine it was supposed to be coal, but on going down the Albertite was found to occupy a well defined fissure vein which pinched out in depth.

Mr. COSTE—The very fact, which Dr. Adams has just pointed out viz.: that the shales are impregnated with bitumens, shows that the "Albertite" vein was not formed by the drainage from the shales into the vein because, if it were, there would be no petroleum or bitumen in the shales now. You cannot eat your cake and have it still. Evidently if the oil of the shales drained into that fissure there would be no more in the shales especially near the fissure and there on the contrary, is where we find the shales impregnated with oil. Show me in nature to-day where entombed fish remains produce oil. How can you admit that these remains produced oil in Lower Carboniferous time when you cannot show the same process in active operation to-day? You cannot even show me any place to-day where bodies of fishes are entombed in the process of rock formation as these bodies decay and burn before entombment takes place.

If animal organic bodies are not entombed in the rocks at the time of the formation of the rocks how can you get them afterwards to decompose in rocks in which they are not. It is quite unnecessary to go miles under the earth to see that animal bodies do not get entombed in rock formations :—it can be seen every day along thousands upon thousands of miles of sea coast line.

Because a small part of the bitumen included in the cubic miles of shales is found in that vicinity oozed out into a fissure, there is no just ground for concluding that all the bitumen in the series should have disappeared. I can imagine the chill which our honored Secretary would experience if every time he poured a few drops out of the bottle, he observed that the bottle became entirely emptied.

Dr. ADAMS—If I could take Mr. Coste down five or ten miles under the earth's crust I think I could demonstrate the process but unfortunately because our spirits are harbored in bodies that cannot pass through shales I cannot prove it. Perhaps in another world under more favourable conditions we may investigate the matter together.

Mr. COSTE—If they are not entombed at the time the formation is made on the sea shore how can you get it afterwards ?

Dr. GOODWIN—I should like to point out that the human mind is prone to prepossession. There are illustrations of that on every hand and I am very much inclined to think that geologists have prepossession in favor of the organic origin of carbon and hydrocarbons in nature. That prepossession is very natural. The origin is that in nature as we have it on the surface of the earth, we cannot disassociate carbon and hydrocarbons from the leaf matter, so we say we get our carbon and our hydrocarbons, everything except carbon dioxide from this leaf matter and it is natural for geologists to rush to the conclusion that all these materials which we find in the crust of the earth have ultimately an organic action, lending a sort of appearance to the prepossession of which Mr. Coste has been accused.

Dr. ROBERT BELL—I beg to move a vote of thanks to Mr. Coste for his paper. I do not think I ever in my life listened to a more interesting paper. As Dr. Adams has suggested, the members of this Institute should give their opinions on it by correspondence and this correspondence including Mr. Coste's paper would make a pamphlet of very great interest.

Mr. MILLER—I beg to second the vote of thanks to Mr. Coste. We are very proud of Mr. Coste in Ontario and as Toronto is his city I think the Institute might have one meeting there if only for educational purposes to let the people know what kind of an Institute we have. There are a great many questions asked about what we are, by politicians and legislators. A great many people in Ontario seem to believe in the volcanic theory. We see that Professor Mickle believes in it: and he made up that conundrum at the time he was discovering the anthracite at Sudbury (Laughter). I had occasion to examine the well which they were putting down and when they got to the granite, I told them that it was time to stop but they went on and are going on still. They seem to think they will get oil down there. It reminds me of the story of the farmer who was digging in the ground and was asked if he was looking for a ground hog. He answered no, but he continued to dig and when he was asked: "What do you think you will get," he replied; well if I keep on I will get oil, hell, or China (Laughter).

The thanks of the Institute were accorded to Mr. Coste.

THE EXAMINATION OF MAGNETIC ORE DEPOSITS BY MEANS OF MAGNETIC MEASUREMENTS.

Dr. **EUGENE HAANEL**—Dominion Supt. of Mines, Ottawa, was down for a paper "On the Principles Underlying the Determination of the Location and Extent of Magnetic Ore Bodies by Magnetic Surveys." Dr. Haanel announced at the opening of his address: I have changed the title of my paper. I find it would be scarcely of much value to speak in a summary way on the principles underlying the method, and as I wanted to make the paper more practical I have changed the title to "The Examination of Magnetic Ore Deposits by Means of Magnetic Measurements."

Dr. **HAANEL** delivered a most interesting and erudite address on his subject, which he illustrated by diagrams on the black-board.

At the conclusion of the address

The **PRESIDENT** said: We are indebted to Dr. Haanel for his interesting and instructive paper. I am sorry we had not an opportunity to call upon him earlier in the day when we could have given him more time. Under the circumstances I do not think we have enabled him to do justice to his subject. There is no doubt that he has made the very best of it in the short space of time which he has had at his disposal.

Mr. **INGALL**—Dr. Haanel has given us an outline, and a very interesting one, of a handbook which he is going to write on this subject. I may say that he has got all the information that he could possibly get in such concise shape, that those of us who wish to follow up the Swedish method will have something to show us exactly how things may be done. I have no doubt that Dr. Haanel's book will be of great value to the mining men of this country. I have always held that in the Kingston and Pembroke districts, for instance, where there are so many bodies of magnetite, that had magnetic surveys been made, many deposits would have been brought forward to our great profit. The information which Dr. Haanel will impart in his book will doubtless be of great use to the mining people of this country.

Mr. MICKLE—Could Dr. Haanel tell with certainty the difference between a mass of rock 20 or 30 per cent. magnetite near the surface, and a body of magnetite at any depth below the surface?

Dr. HAANEL—I have indicated that it cannot be done in a case of that kind. That can only be done by boring.

Dr. GOODWIN—I realized last summer the importance of this method of magnetic survey. Dr. Haanel's clear and lucid explanation of the principles of this survey has removed certain doubts from my mind which I had as to its applicability. I trust that what Mr. Ingall has said about the publication of the hand book does not mean that we are not going to have the honour of publishing this paper in our Journal, because I think it would be very important indeed to have it published in the Journal of this Institute so that it may receive the widest possible circulation. (Hear, hear). I have much pleasure in moving that the thanks of the Institute be tendered to Dr. Haanel for his very important paper.

Dr. PORTER—I have much pleasure in seconding the vote of thanks to Dr. Haanel, and in doing so I should like to speak of my own experience in attempting to learn something of this method. I am not able to read the Swedish work on the subject in the original, and I have had considerable difficulty in the last year or two in getting any satisfactory information on the subject. I tried in England and Germany and failed. At McGill University, Dr. Adams and I have both appreciated the importance of this Swedish method and I might say that the Geological Department, under Dr. Adams, has recently procured some of the most modern apparatus for this magnetic survey and we are putting it in as a very important part of our Geological course. I think this field has been very much neglected until recently in this country, and we want to make the very best effort we can in the future to remedy our omissions in the past. Dr. Haanel's book will be welcomed not only by people who teach, but by many people in the field. I have had from my old students and from others many enquiries within the last year as to where in the world they could get information with regard to this method of survey, and heretofore I have had to send them a long list of very unsatisfactory references. I hope when Dr. Haanel publishes his book that I will be able to send them a single reference which will not be unsatisfactory.

The vote of thanks was enthusiastically passed.

The meeting adjourned at 11 o'clock to meet on Friday morning.

FRIDAY MORNING SESSION.

The Institute met at 11 o'clock on Friday morning in the library. Mr. Charles Fergie, President, occupied the chair.

An informal discussion took place as to where the next annual meeting should be held, but this discussion was renewed afterwards on a motion to hold the meeting in Toronto as appears by the report later.

ELECTION OF OFFICERS.

The scrutineers having examined the ballots, reported that the Officers and Council selected by the nominating committee had been elected.

MR. COSTE TAKES THE CHAIR.

Mr. B. T. A. BELL—It is now in order that our President Mr. Coste, who, by the declaration of the ballot, will fill the office for the ensuing year, take the chair. In Mr. Coste we have one of the oldest consulting mining engineers in Canada, and a gentleman who has consistently earned a very high reputation as an engineer and geologist. (Applause.) In so far as the proceedings of our Institute are concerned we may congratulate ourselves upon having on record two papers from him which are decidedly unique and original and distinctly creditable to Mr. Coste and to our Institute. (Applause.) I have great pleasure in moving that Mr. Coste now take the chair.

Mr. COSTE then took the chair as President of the Institute and was received with hearty applause and congratulations. He said : I thank you very much for the honor you have conferred upon me in electing me to be President of the Canadian Mining Institute, a position which has always been worthily filled by men of distinction in the past. My only fear is that I may not be able to discharge the duties of the office so well as my predecessors have done, but I assure you that I shall do my best. (Applause). With due regard to your choice I think you could have selected a better man, and indeed I see around me in this room many gentlemen who I think are more fitted for the position than I am. I should like to make a few brief remarks as to the progress of our Institute during the past few years. The figures given in the report of the Council show that we are in a very healthy condition indeed. We have now 453 members and our official publications are very creditable to the Institute and to the mining men of the country. Indeed, I may say, that from year to year our publications are improving all the time. We have always held good meetings and that is one of the things necessary to keep matters going. We also have a very satisfactory financial statement to present and a substantial balance on hand. We owe that in large part to the kindness of the Dominion Government in granting us an extra $2,000 last year and it is fitting for us to record our appreciation of this grant and to thank the Honorable Mr. Sifton, Minister of the Interior, for his kindness in that regard. We can also express the hope that at least the same grant will be renewed for next year. We want to get at least as much money as we had last year, because as our Treasurer has pointed out, we have a good deal more to publish this year. In the discussion which took place, speaking about a meeting in Toronto, I referred to the fact that in Ontario they have never seen this Mining Institute, and some people there imagine that there is no such thing as a Mining Institute or no body of men chartered into an Association which represents the mining interests of the whole country from one end to the other. From that erroneous idea arose a very queer situation in Toronto some little time ago which fortunately was called to our attention in time by our Secretary. Major Leckie was also in Toronto and with Bell and myself there was a corporal's guard of us to tell some scheming politicians up there, that they should not imagine that they could hold a properly accredited mining convention in this country without us. They had the gall notwithstanding to appoint, at that bogus mining convention in Toronto, a credential committee which went through the farce of pretending to collect credentials from those present when not one person there had any credentials of any kind, and to dare to proclaim themselves openly a representative mining body of the Province. I think that is partly due to our mistake in not having occasional meetings in Toronto, and I trust that the suggestion made to have a meeting there will take shape. We will have a very fine new hotel there next year and you could not go to a better place. I conclude by thanking the members of the Mining Institute for the honor they have done me. (Applause).

THANKS TO MR. FERGIE.

Mr. J. STEVENSON BROWN—It would be in order now for some mining man to propose a vote of thanks to Mr. Fergie, who has so well presided over the Institute during the past year. I know something of the services which Mr. Fergie has rendered and I know that at very considerable inconvenience to himself he has travelled very long distances on several occasions simply to attend our Council meetings, a fact which shows that he took great interest in the society.

Mr. HARDMAN—Our treasurer desires that this motion should come from a mining man and in compliance with his request I have much pleasure in moving that the thanks, the most cordial thanks of the Institute, be given to Mr. Charles Fergie for the able manner in which he presided over our meetings during the past year.

MAJOR GEORGE SMITH, M.L.A., seconded the motion.

The PRESIDENT—(Mr. Coste). In speaking of the progress our Institute has made during the past year, I should certainly have mentioned that this progress was due in large part to the efforts of our President Mr. Fergie. I ask you gentlemen to pass that motion with hearty applause.

The members of the Institute enthusiastically endorsed the motion.

Mr. HARDMAN—I beg to move that the thanks of the Institute be tendered to the Secretary and to the Treasurer both of whom have rendered valuable services and have been present at every meeting of the Council.

Mr. A. W. STEVENSON—I second that motion. It makes a very strong combination for the good of any society when you have such a Secretary, such a Treasurer and such a President as we had last year. I have no doubt that our Institute will continue to grow and increase and that we will have a membership of 1000 instead of 500 as at present.

The motion having been put by the President it was cordially received and the thanks of the Institute were tendered to Mr. B. T. A. Bell, Secretary, and to Mr. J. Stevenson Brown, Treasurer.

Mr. B. T. A. BELL—While votes of thanks are in order we must not forget the services rendered to the Institute during these meetings by Dr. Porter. He has gone to great personal trouble to provide us with the use of an excellent lantern and in many other ways he has done much to promote the success of the gathering.

Mr. HARDMAN seconded the motion which was adopted.

The PRESIDENT in tendering the thanks of the Institute to Dr. Porter, said that every year they had met in Montreal they had experienced uniform kindness from him

Mr. B. T. A. BELL -With regard to the proposal to move a vote of thanks to Honorable Mr. Sifton for the grant to the Institute, I may say that the Honorable Mr. Fielding has also been very considerate to us. We have already expressed in very clear and precise language our appreciation of the Government grant, and we all hope it may be renewed.

TORONTO FOR NEXT ANNUAL MEETING.

After some discussion a motion was passed recommending to the Council the desirability of holding the next annual meetings of the Institute in the city of Toronto.

MONTREAL BRANCH OF QUEBEC MINING BUREAU.

Mr. T. J. DRUMMOND—We have felt for a long time in the City of Montreal that it was very desirable that there should be a branch in this City of the Mining Department of the Quebec Government. A great many people who visit Montreal and who might be interested in our mining development often do not find it convenient to go to Quebec City, and if we could have the mining exhibits and information here it would be a great assistance. I beg to move seconded by Mr. Stevenson :

" Resolved that this Institute through its officers urge on the Government of the Province of Quebec the necessity and importance of establishing in the City of Montreal a branch office of the Department of Mines. Such branch office to contain all necessary exhibits, maps and other information in regard to the Mining interests of the said Province, and to be the Head quarters of the Director of Mines of the Province of Quebec, and under his immediate supervision. This Institute being of the opinion that the establishment of such an office in the City of Montreal would be in the interests of the Province of Quebec and of the Dominion at large."

I do not believe that it would at all interfere with the Mining Department if the Provincial Inspector of Mines had his headquarters in Montreal. If he were here it would be possible to get this information for those interested in mining matters who visit Montreal, and they could see at great convenience to themselves the exhibits and plans and maps. The carrying out of this resolution would entail little or no expense upon the Government. I believe that if the Institute passes this resolution it will be favourably considered by the Provincial Government.

Mr. A. W. STEVENSON—There is no politics in this ; it is simply a business consideration. We have already interviewed the Quebec Government and they appear to be generally in favor of the proposition, but of course we have a very economical Government in this Province, and it may be that the question of possible expense bothers them more than anything else. An expression of opinion by this Institute might help the Minister in arriving at a decision.

Mr. OBALSKI, Inspector of Mines, Province of Quebec—I would like to say a few words on the question as I am somewhat interested. I find quite an unanimity of opinion on this subject, and I have been approached by several members with a view of getting my opinion. Some years ago I had some objections to come to Montreal for a private reason, and also because I had charge of the Administrative work of the Department. Now we have a very efficient officer in Mr. Coté who has charge of the administrative part of this branch. Our province as you know extends from Temiscaminge to Gaspé, and I think it would be very convenient for the mining community and for people visiting our country to have an office here. For my part I would be willing to come to Montreal. I have been twenty-two years in the service of the Government ; I have done my best in the past and I intend to do the same in the future. I have no doubt but that the Government will consider this matter carefully.

The PRESIDENT—You all seem to agree on this point and I myself believe that it would be a great benefit to mining interests if we had an office of the Inspector of Mines for Quebec in Montreal. The resolution was adopted unanimously.

The SECRETARY—I wish to make an announcement with regard to the Students' competition. I think that the committee on awards would be more effective if it is a small committee. We have divided the awards into three classes. It is one of the perquisites of being the President of the Institute that he has to give a gold medal every year, and the President's medal is given for the best paper contributed during the year. We have divided the subjects, one under Mining, one under Ore Deposits and Geology; and the other under Ore Dressing. I would suggest that the awards in the mining and metallurgical section should be left to Messrs. Coste and Hardman, and that the geological section awards be left to Dr. Adams, of McGill, Prof. Walker, of Toronto and Dr. Goodwin of Queen's. I think this will make a very good committee.

The PRESIDENT—In regard to the medal I may say that I will be very pleased indeed to contribute the usual medal and in fact I look upon it as an honor to be allowed to do so.

The Committee named by Mr. Bell was appointed.

FRIDAY AFTERNOON SESSION.

The Institute re-assembled on Friday afternoon at 3 o'clock.

The President, Mr. Coste, occupied the chair.

NICKEL DEPOSITS OF NEW CALEDONIA.

Major R. G. LECKIE, of Sudbury, Ont., read his interesting paper, "On the Nickel Mines of New Caledonia." Major Leckie spoke from a personal examination of the mines and gave facts and figures of deep concern to the nickel industry in Canada. He also exhibited some very interesting photographs of the mines and their working, which were taken on the ground.

The PRESIDENT—We are all deeply indebted to Major Leckie for his paper, which is so interesting, and so much to the point, there being a similar association of rocks with the nickel found in our own country.

Major G. R. SMITH—I have listened with the greatest interest to what Major Leckie has said in connection with the nickel mines of New Caledonia, and with the hope, as he suggests that it may lead to some further development of our deposits in the Eastern Townships, although I am frank enough to say that there does not appear to be enough work done in the Eastern Townships to start a company on yet. When we see that they are working with such low grade ores in New Caledonia there is hope for us.

Mr. W. G. MILLER—Major Leckie is well qualified to give us a description of the New Caledonia mines, and to make this comparison with Quebec on account of his earlier experience in that province. I must say that it is a very valuable comparison indeed. It is always interesting to have our own mines compared with those of other places, even if we have not found very much in any one locality in Quebec yet.

Mr. G. R. MICKLE—Did I understand Major Leckie to say that there were a great many nickel deposits in New Caledonia that are still undeveloped?

Major LECKIE—Oh no.

Mr. G. R. MICKLE—But none of them extend to any depth.

Major LECKIE—No.

Mr. G. R. MICKLE—Would the quantity be immense.

Major LECKIE—Oh yes. There is one place where the International Nickel Co., bought about 8,000 acres all covered with more or less of this silicate of nickel. There is no blasting required there; it simply is necessary to have an efficient Chinaman to pick it up. The work is done by pick and shovel.

The PRESIDENT—How many miles does the range extend?

Major LECKIE—The known range is about three-quarters the length of the Island, or 150 miles; it is very continuous.

Mr. EVANS—Do I understand that the depth of the deposit is about 20 feet.

Major LECKIE—Yes; and after that you get into the pure serpentine.

Mr. EVANS—20 feet would be the maximum.

Major LECKIE—Yes; 20 feet or 25 feet would be the maximum.

Mr. FERGIE—How would you compare these mines with the mines in Canada.

Major LECKIE—The best mines in New Caledonia would hold their own with the best mines in Canada. There are only one or two mines in Canada that would equal them in cost of production.

Mr. FERGIE—I understood you to say that there was 25 per cent. of moisture in the New Caledonia ores.

Major LECKIE—Yes; from 10 per cent. to 25 per cent. There is no water in the Canadian; it is a hard sulphide, the New Caledonia ore is free from sulphur and phosphorus. The only metal associated with nickel there, is iron so that if it were smelted you could form a ferro-nickel. Experiments have been made and it yielded ferro-nickel carrying 48 to 52 per cent. of nickel and the balance iron. There are immense quantities of iron there, The difficulty in making the ferro-nickel from our Canadian ores is the amount of sulphur they carry, and also copper. If you would make a ferro-nickel for the use of steel-makers you must have it entirely free from sulphur, which is fatal to steel. Copper also is very injurious to steel. You could use up to one-tenth of one per cent. of copper, but it is a very costly thing to get rid entirely of the copper from the matte. Dr. Mond extracts copper as sulphate and then treats the residue with carbonic oxide which dissolves the nickel in that way, and a certain amount of iron is carried over with the nickel. But if the matte can be brought into a condition where nothing remains but iron and nickel you could then fuse that at once and make a ferro-nickel and save a very costly process, namely, the fusion half a dozen times with the sulphate of soda in order to separate the nickel from the copper. The ores of New Caledonia being quite free from sulphur and copper and phosphorus, they lend themselves very readily to the production of ferro-nickel of high grade. Formerly the French company did some smelting in New Caledonia, and the product was rather an infusible mixture. We know that the silicate of any metal is rather difficult to work , it is not like smelting the oxide. The great consumption of nickel now is not as metallic nickel, but it is used as an oxide or as a ferro-nickel for making steel rails, armour plates, and all that sort of thing. There is no necessity for getting rid of the iron if you could give a ferro-nickel perfectly free from sulphur and free from copper. That is the problem before our Canadian metallurgists. It is to get rid of the sulphur and the copper and form ferro-nickel. Mr. Clergue has tried it and failed, as I told him he would, some years ago.

Mr. BROCK—Major Leckie has rendered an important service in calling attention to this mode of occurrence of nickel. Districts which may be prospected for nickel in this form are not confined to the Eastern part of Canada. As has been pointed out there are similar nickel deposits in Oregon, and in British Columbia there are immense areas of serpentines which might be nickeliferous.

A great part of British Columbia has not been carefully worked over geologically, but in the Atlin district, and in Central and Southern British Columbia, are large areas of serpentine, formed by the alteration of basic peridotic or pyroxenic rocks very similar to those of the Eastern Townships or New Caledonia. They contain at some points, chromite and in places as in the Similikameen District, platinum. At some points a brown weathered product occurs on the surface which resembles in appearance the brown ore of New Caledonia. It would be well for prospectors to bear in mind the possibility of nickel occurring in such serpentines.

The basic country rock of the Sudbury district is closely allied in composition to pyroxenite, except that being somewhat more acid, feldspar has formed in it. From some experiments which I made on some of the Sudbury rocks it was shown that nickel does occur in small quantities in some of the basic constituents of these rocks.

The PRESIDENT—I was in hopes when Major Leckie described the superficial deposits in New Caledonia that we might hope to see an end to it before very long in order that our Canadian deposits would be more valuable. That is a selfish idea no doubt, but it is a very natural one. However when Major Leckie further said that the deposits were found 150 miles in length. I am afraid we will have something to tackle in trying to keep our end up. On the other hand I am very much consoled by Mr. Brock's view that we have not only these magnesian igneous rocks in the Eastern Townships, but also in British Columbia, and all along our Pacific Coast, more or less.

The thanks of the meeting were accorded to Major Leckie.

PRIMITIVE MINING AND SMELTING IN INDIA.

Prof. T. L. WALKER of Toronto University delivered an address "On some Primitive Methods of Mining and Smelting in India (Illustrated by lantern projections).

Prof. WALKER spoke from personal experiences in India and Ceylon and his photographs taken by himself on the spot, portrayed the primitive methods of gold washing, iron smelting and mica mining. He pointed out how whole families were engaged in this labor and were paid at the rate of 2 cents a day each, while the manager of a mine would get $5.00 a month.

At the conclusion of the address, in reply to questions, he stated that in the mines represented by the Government of India there was a royalty of 10 per cent. and in mines which belonged to the great native princes the mining was done as a matter of bargain. When the mica was shipped to England and sold, the bills of sale were returned and the royalty was collected on that. Prof. Walker also explained the geological formation in which the mica was found in India.

A cordial vote of thanks was tendered to Prof. Walker.

Mr. W. G. MILLER, Provincial Mineralogist, Toronto, was on the syllabus for a paper on "Notes on the History of the Mineral Industry in the Nineteenth Century."

As the time was limited Mr. Miller gave but a brief summary of his paper and he illustrated, by diagrams, the production of minerals in different countries during the last two centuries.

The address of Prof. Miller was most interesting and at its conclusion the President in tendering the thanks of the Institute to him, regretted that time did not permit to hear the paper read *in extenso* but that they all felt there would be much benefit derived from it when it was printed in the Journal of the Institute.

The meeting then adjourned.

ANNUAL DINNER.

The Annual Dinner in the evening was one of the most successful functions held by the Institute and was largely attended.

TRANSACTIONS

OF

The Canadian Mining Institute

INDICES

TO

Names of Authors and Subjects

Of the Papers presented to The Canadian Mining Institute, The Federated Canadian Mining Institute, and the antecedent Provincial Mining Societies.

1891 TO 1903.

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